SOIL SURVEY OF

Ward County, Texas

ELECTRONIC VERSION

This soil survey is an electronic version of the original printed copy, dated January 1975. It has been formatted for electronic delivery. Additional and updated information may be available from the Web Soil Survey. In Web Soil Survey, identify an Area of Interest (AOI) and navigate through the AOI Properties panel to learn what soil data is available.

United States Department of Agriculture
Soil Conservation Service
In cooperation with
Texas Agricultural Experiment Station

Major fieldwork for this soil survey was done in the period 1964-68. Soil names and descriptions were approved in 1969. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1968. This survey was made cooperatively by the Soil Conservation Service and the Texas Agricultural Experiment Station. It is part of the technical assistance furnished to the Upper Pecos Soil and Water Conservation District.

Copies of the soil map in this publication can be made by commercial photographers, or they can be purchased on individual order from the Cartographic Division, Soil Conservation Service, United States Department of Agriculture, Washington, D.C. 20250.

HOW TO USE THIS SOIL SURVEY

This soil survey contains information that can be applied in managing farms and ranches; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

Locating Soils

All the soils of Ward County are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

Finding and Using Information

The "Guide to Mapping Units, (Removed)" can be used to find information. This guide lists all the soils of the county by map symbol and gives the capability classification of each. It also shows the page where each soil is described and the page for the range site in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

Farmers and those who work with farmers can learn about use and management of the soils from the soil descriptions and from the discussions of the range sites.

Game managers, sportsmen, and others can find information about soils and wildlife in the section "Use of the Soils for Wildlife."

Ranchers and others can find, under "Use of the Soils for Range," groupings of the soils according to their suitability for range, and also the names of many of the plants that grow on each range site.

Community planners and others can read about soil properties that affect the choice of sites for dwellings, industrial buildings, and recreation areas in the section "Interpretations for Town and Country Planning."

Engineers and builders can find, under "Engineering Uses of the Soils," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

Scientists and others can read about how the soils formed and how they are classified in the section "Formation and Classification of the Soils."

Newcomers in Ward County may be especially interested in the section "General Soil Map." where broad patterns of soils are described. They may also be interested in the information about the county given in the section "Additional Facts About the County."

Contents

SOIL SURVEY OF WARD COUNTY, TEXAS

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IN COOPERATION WITH THE
TEXAS AGRICULTURAL EXPERIMENT STATION

Ward County is in the western part of Texas. It is bordered on the east by Crane County and on the north by Ector, Winkler, and Loving Counties. It is separated from Reeves and Pecos Counties on the west and south by the Pecos River (fig. 1). The county is roughly rectangular. It is approximately 44 miles from east to west and ranges from 15 to 26 miles from north to south.

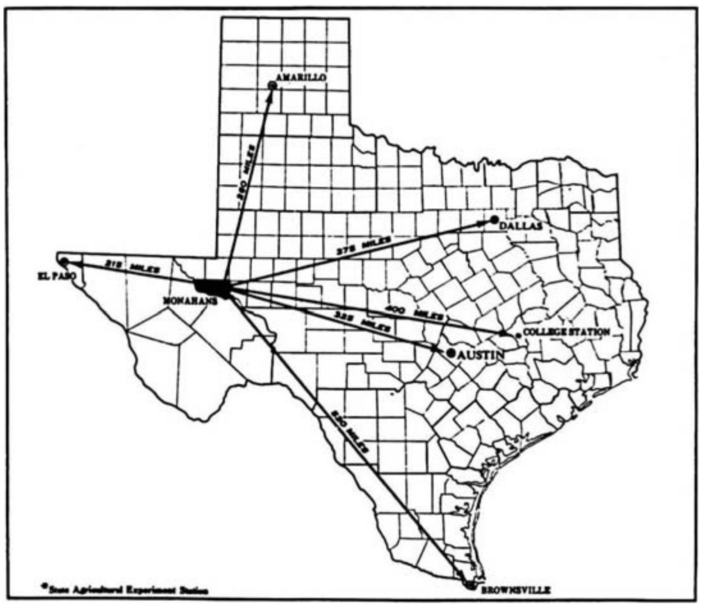

Figure 1.—Location of Ward County in Texas.

The total area of the county is approximately 529,280 acres, or 827 square miles. Approximately 42,000 acres is used for cropland, built-up areas, highways, and other purposes. About 8,000 acres is used as irrigated cropland. The acreage of irrigated cropland fluctuates from year to year, depending on the amount of irrigation water available from Red Bluff Reservoir. The Ward County Improvement Districts 1, 2, and 3 administer and regulate the delivery and quantity of irrigation water.

Alfalfa is grown both for hay and seed production and is the main crop. Cotton is grown where water is available.

The average annual precipitation is 11.11 inches. Precipitation is least in winter and spring. Most of the precipitation falls in summer and fall.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Ward County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey (*10*).

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Harkey and Ima, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Harkey loam is a phase in the Harkey series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this publication was prepared from aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some kind that have been seen within an area that is dominantly of a recognized soil phase.

Some mapping units are made up of soils of different series, or of different phases within one series. Two such kinds of mapping units are shown on the soil map of Ward County: soil associations and undifferentiated groups.

A soil association is made up of adjacent soils that occur as areas large enough to be shown individually on the soil map but are shown as one unit because the time and effort of delineating them separately cannot be justified. There is a considerable degree of uniformity in pattern and relative extent of the dominant soils, but the soils may differ greatly one from another. The name of an association consists of the names of the dominant soils, joined by a hyphen. Los Tanos-Courthouse association is an example.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or of two or more. Wickett and Sharvana soils gently undulating, is an undifferentiated soil group in this county.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Ward County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed or a wildlife area, or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field, or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The soil associations in Ward county are discussed in the following pages. The terms for texture used in the title for several of the associations apply to the texture of the surface layer. For example, in the title of association 5, the words "clayey and loamy" refer to the texture of the surface layer.

1. Pyote association

Sandy, gently undulating soils on uplands

This association occupies large, gently undulating areas.

The soils in this association make up approximately 34 percent of the county. About 75 percent is Pyote soils, and the remaining 25 percent is Kinco, Sharvana, and Wickett soils.

Pyote soils have a yellowish-red, mildly alkaline loamy fine sand surface layer about 12 inches thick. The next layer is reddish-brown, mildly alkaline loamy fine sand 22 inches thick. Below this, to a depth of 50 inches, is reddish-brown, mildly alkaline fine sandy loam. The next layer, to a depth of 62 inches is yellowish-red, moderately alkaline fine sandy loam. The underlying material, to a depth of 76 inches, is pink, moderately alkaline fine sandy loam that contains threads, films, and soft masses of calcium carbonate.

This association is used mostly for range. A few areas were once cultivated but are now abandoned. This association is well suited to range.

2. Delnorte-Sharvana association

Loamy, nearly level to undulating soils on uplands

This association occupies broad areas on uplands.

The soils in this association make up approximately 31 percent of the county. About 60 percent of this is Delnorte soils, and about 27 percent is Sharvana soils. The remaining 13 percent is Courthouse, Los Tanos, McCarran, Upton, and Verhalen soils.

Delnorte soils have a pale-brown, moderately alkaline gravelly loam surface layer about 8 inches thick. The next layer, to a depth of 20 inches, is white, cemented to indurated caliche. The underlying material, to a depth of 60 inches, is very pale brown gravelly fine sand.

Sharvana soils have a brown, mildly alkaline fine sandy loam surface layer about 4 inches thick. The next layer is brown, mildly alkaline fine sandy loam about 6 inches thick. Below this, and extending to a depth of 19 inches, is a pinkish-white, moderately alkaline, cemented mass of calcium carbonate that has brown fine sandy loam in the cracks between the calcium carbonate fragments. The next layer, to a depth of 26 inches, is pink, indurated caliche plates.

This association is used for range. Shallow soil depth and low rainfall are limitations on the soils of this association.

3. McCarran association

Loamy, nearly level soils on uplands

This association occupies broad areas on uplands.

The soils in this association make up approximately 10 percent of the county. McCarran soils make up about 90 percent of the association. The remaining 10 percent is mainly Pyote, Delnorte, Monahans, and Upton soils.

McCarran soils have a surface layer of pale-brown, moderately alkaline loam about 4 inches thick. The next layer is very pale brown, moderately alkaline silt loam about 6 inches thick. The underlying material, to a depth of 15 inches, is white, gypsiferous loam. There are small, circular areas where the gypsum layer is exposed or where the surface layer is less than 1 inch thick. This association is used mostly for range.

4. Monahans-Ima association

Loamy, nearly level to gently sloping soils on uplands

This association occupies an ancient terrace adjacent to the Pecos River flood plain.

The soils in this association make up approximately 10 percent of the county. About 45 percent of this is Monahans soils, and about 26 percent is Ima soils. The remaining 29 percent is Hodgins, Upton, and McCarran soils.

Monahans soils have a pale-brown, moderately alkaline fine sandy loam surface layer 8 inches thick. The next layer is light-brown, moderately alkaline sandy clay loam about 20 inches thick. The underlying material, to a depth of 60 inches, is pink, moderately alkaline sandy clay loam that is about 15 percent gypsum crystals and soft masses of calcium carbonate.

Ima soils have a brown, moderately alkaline, fine sandy loam surface layer 10 inches thick. The next layer, to a depth of 34 inches, is reddish-yellow, moderately alkaline fine sandy loam that contains a few igneous pebbles and calcium carbonate fragments. Below this, to a depth of 72 inches, is light-brown, moderately alkaline fine sandy loam.

This association is used for both irrigated crops and native range. About 40 percent of this association is used for irrigated crops when irrigation water is available.

5. Arno-Gila association

Clayey and loamy, nearly level soils on flood plains

This association occupies nearly level areas on the Pecos River flood plain.

The soils in this association make up approximately 8 percent of the county. About 30 percent of this is Arno soils, and about 17 percent is Gila soils. The remaining 53 percent is Delnorte, Harkey, Hodgins, Ima, McCarran, Monahans, Pecos, and Toyah soils.

Arno soils have a reddish-brown, moderately alkaline clay surface layer 8 inches thick. The next layer is reddish-brown, moderately alkaline clay that has a few thin strata of silty clay and extends to a depth of 41 inches. Below this, to a depth of 60 inches, is light olive-brown, moderately alkaline silty clay that has masses and threads of gypsum and other salts.

Gila soils have a brown, moderately alkaline fine sandy loam surface layer about 16 inches thick. The next layer is light yellowish-brown, moderately alkaline fine sandy loam that has a few thin bands of silty clay loam extending to a depth of 44 inches.

About 10 percent of this association is used for irrigated crops. The rest is in native range.

6. Kermit-Dune land association

Sandy, gently undulating to hummocky soils on uplands

This association occupies areas that are hummocky and duned.

The soils in this association make up approximately 7 percent of the county. About 50 percent of this is Kermit soils, and about 44 percent is Dune land. The remaining 6 percent is Pyote, Sharvana, and Wickett soils.

Kermit soils are very pale brown, neutral fine sand to a depth of about 60 inches. The underlying material is light yellowish-brown neutral fine sand.

Dune land consists of dunes that are oriented with the prevailing southwesterly winds. Some of the large dunes are isolated and are 3 to 20 acres in size. The dunes also occur in a series and cover as much as 3,000 acres (for example, Monahans Sandhills State Park).

All of this association is in native range or is used for recreation.

Descriptions of the Soils

This section describes the soil series and mapping units in Ward County. Each soil series is described in detail, and then, briefly, each mapping unit in that series. Unless it is specifically mentioned otherwise, it is to be assumed that what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second is much more detailed and is for those who need to make thorough and precise studies of soils. The profile described in the series is representative for mapping units in that series. If the profile of a given mapping unit is different from the one described for the series, these differences are stated in describing the mapping unit, or they are differences that are apparent in the name of the mapping unit. Color terms are for dry soil unless otherwise stated.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit and range site in which the mapping unit has been placed. Some mapping units are placed in both dryland and irrigated capability units. Others are placed only in dryland units because irrigating them is not considered feasible under present conditions of water supply and drainage. Most irrigation water in this county contains toxic salts. If irrigation water were of higher quality and drainage were good, soils now rated unsuitable for irrigation would be suitable.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary.

Arno Series

The Arno series consists of deep, calcareous, clayey soils containing gypsum and other salts. These soils formed in stratified, calcareous and saline, clayey alluvial sediment. They are in smooth areas on the Pecos River flood plain.

In a representative profile, the surface layer is reddish-brown clay that is about 8 inches thick and is extremely hard when dry. Below the surface layer and extending to a depth of 41 inches, is reddish-brown, calcareous clay that is massive and that cracks when it is dry. Below this, to a depth of 60 inches, is massive, light olive-brown, extremely hard silty clay.

Arno soils are moderately well drained. Runoff is slow, and permeability is very slow. These soils have high to very high salinity.

Arno soils are not suitable for cultivation under irrigation because of salinity and very slow permeability. They have been flooded in the past, but not more than once in the past 25 years.

Representative profile of Arno clay in a formerly cultivated field 100 feet west of an unimproved road from a point 2.1 miles south of Farm Road 873 and 2.5 miles northwest of the community center of Barstow:

Ap—0 to 8 inches, reddish-brown (5YR 5/4) clay, reddish brown (5YR 4/4) moist; massive (structureless); extremely hard, extremely firm, very sticky and very plastic; few fine and medium roots; few fine pores; many, very fine, soft masses of calcium sulfate and other salts; cracks 0.2 to 0.4 inch wide; saline; calcareous, moderately alkaline; clear, smooth boundary.

C1—8 to 41 inches, reddish-brown (2.5YR 4/4) clay, dark reddish brown (2.5YR 374) moist; massive (structureless); extremely hard, extremely firm, very sticky and plastic; few fine and medium roots; few fine pores; cracks 0.4 inch wide extend to lower boundary; few nonintersecting slickensides; few thin strata of silty clay; many fine and medium threads and elongated masses of calcium sulfate and other salts on faces of bedding planes and slickensides; partially decayed plant remains on some bedding planes; saline; calcareous, moderately alkaline; gradual, smooth boundary.

C2—41 to 60 inches, light olive-brown (2.5YR 5/4) silty clay, olive brown (2.5Y 4/4) moist; massive (structureless); extremely hard, extremely firm, very sticky and plastic; many fine and medium soft masses and threads of calcium sulfate and other salts; saline; calcareous, moderately alkaline.

Thickness of the soil to a horizon of contrasting texture or to bedrock ranges from about 50 inches to more than 100 inches. When these soils are dry, they have cracks 0.4 to 1 inch wide to a depth of 20 inches. The A horizon is reddish brown, brown, or light brown. The C horizon is reddish brown, brown, light olive brown, or olive. It ranges from silty clay to clay. The electrical conductivity of the saturation extract of the soil ranges from 10 to 32 millimhos per centimeter.

Arno clay (Ar).—This soil is nearly level and has slopes of less than 1 percent. Areas range from 80 to 1,000 acres in size and are long and narrow or irregular in shape.

Included with this soil in mapping are small areas of Pecos, Patrole, and Harkey soils. These included areas are 2 to 6 acres in size and occupy the same position on the landscape as this Arno soil.

Large areas of this soil have been used in the past for irrigated crops but are now mostly abandoned. The present salt concentration is above the salt tolerance of most crops. Water enters this soil rapidly when it is dry and cracked but very slowly when it is moist. At times the surface forms a hard crust as much as one-half inch thick that makes it difficult for seedlings to emerge. Capability unit VIIi-4 (dryland); Salty range site.

Courthouse Series

The Courthouse series consists of shallow, calcareous, loamy soils that formed in material weathered from sandstone. These soils are in eroded areas on uplands. Slopes are convex and range from 4 to 12 percent.

In a representative profile, the surface layer is red fine sandy loam about 12 inches thick and is 30 percent, by volume, plates and fragments of caliche. The underlying material is a thick layer of red, strongly cemented sand-stone fragments 1 to 2 inches thick and 8 to 14 inches in diameter along their long axis.

Courthouse soils are well drained. Runoff is medium to rapid, and permeability is moderate. These soils are free of salts and alkali.

These soils are not suitable for cultivation, because they are shallow. They are used for native range.

Courthouse soils are mapped only in an association with soils of the Los Tanos series.

Representative profile of a Courthouse fine sandy loam in an area of Los Tanos-Courthouse association in native range, 0.7 mile west of a range trail and 7 miles south of U.S. Highway 80, which is 9 miles west of the intersection of Interstate 20 and Farm Road 1927 in Pyote:

A1—0 to 12 inches, red (2.5YR. 5/6) fine sandy loam, dark red (2.5YR 3/6) moist; moderate, fine and medium, subangular blocky and granular structure; hard, friable, sticky; few fine roots; common medium pores; 30 percent, by volume, modular plates and fragments of calcium carbonate; common fine casts and burrows; calcareous, moderately alkaline; abrupt, smooth boundary.

R—12 to 14 inches, red (2.5YR 5/6), strongly cemented sandstone, red (2.5YR 4/6) moist; few fine roots in cracks; fragments are 1 to 2 inches thick and from 8 to 14 inches in diameter; thin discontinuous coatings of calcium carbonate; calcareous, moderately alkaline.

Depth to bedrock ranges from 10 to 20 inches. The A horizon is red or light reddish brown. Caliche, igneous pebbles, and sandstone fragments are throughout the solum and on the surface. Outcrops of sandstone bedrock are common. Coarse fragments range from 25 to 35 percent by volume.

Delnorte Series

The Delnorte series consists of calcareous, gravelly loamy soils that are very shallow to caliche. These soils formed in a bed of gravel and sand that is cemented with calcium carbonate. They are gently sloping and gently rolling to gently undulating and occur in broad areas.

In a representative profile, the surface layer is pale-brown, calcareous gravelly loam about 8 inches thick. The next layer is white, weakly cemented to strongly cemented caliche about 4 inches thick. Below this is about 8 inches of white, indurated caliche. The underlying material, to a depth of 60 inches, is very pale brown gravelly fine sand.

The Delnorte soils are excessively drained. Surface runoff is rapid, and permeability is moderate. These soils are free of salts and alkali.

These soils generally are used for range, but a few small areas are cultivated with surrounding deeper soils.

Representative profile of a Delnorte gravelly loam in an area of Delnorte gravelly soils, undulating, in native range 7.4 miles north of Barstow on Farm Road 516:

A1—0 to 8 inches, pale-brown (10YR 8/3) gravelly loam, brown (10YR 4/3) moist; weak, fine, subangular blocky structure; soft, friable, slightly sticky; few fine and medium roots, tubes, and pores; 40 percent, by volume, angular fragments of caliche 1/4 to 1/2 inch in size; 10 percent, by volume, rounded igneous pebbles 1/4 to 1/2 inch in size; few insect casts and burrows; calcareous, moderately alkaline; abrupt, wavy boundary.

C1cam—8 to 12 inches, white (10YR 8/2), weakly cemented to strongly cemented caliche, light gray (10YR 7/2) moist; imbedded with small igneous pebbles; fragments are 1 to 3 inches thick and 3 to 6 inches in diameter; soil material is in the fractures; abrupt, wavy boundary.

C2cam—12 to 20 inches, white (10YR 8/2), indurated caliche plates 1 to 4 inches thick and 12 to 18 inches in diameter; imbedded with small igneous pebbles; abrupt, wavy boundary.

C3—20 to 60 inches, very pale brown (10YR 7/3) gravelly fine sand, pale brown (10YR 6/3) moist; massive (structureless); loose; 70 percent, by volume, caliche-coated, subrounded limestone and igneous pebbles, mostly less than 2 inches in diameter.

The A horizon ranges from gravelly loam to gravelly fine sandy loam. The clay content ranges from 15 percent to 24 percent. The horizon is 35 to 50 percent, by volume, angular fragments of caliche and rounded igneous pebbles less than 3 inches in diameter. The A horizon is brown or pale brown. Depth to caliche ranges from 6 to 10 inches. The C1cam horizon is weakly cemented to strongly cemented.

Delnorte gravelly soils, undulating (DE).—This undifferentiated group consists of broad areas of soils on uplands. Most of these areas range from 200 to 5,000 acres in size, but a few areas are as much as 22,000 acres in size. The areas are broad and irregular in shape. The slopes are convex and range from 1 to 8 percent. The areas of these soils are dissected by small, intermittent drainageways.

Included with these soils in mapping are small, circular, depressional areas of Verhalen soils 1 to 5 acres in size. Also included are small, oval areas of Upton soils 8 to 20 acres in size.

The soils in this mapping unit are used for native range and as a source of caliche for road-building material. These soils are not suitable for cultivation, because they have a very shallow rooting depth and a high gravel content. Capability unit VIIs-1 (dryland); Gravelly range site.

Dune Land

Dune land consists of active sand dunes that are 16 to 25 feet high and long and narrow. Individual dunes are 3 to 20 acres in size, but are connected with others in a series covering 10 to 160 acres or more. These dunes consist of noncalcareous very pale brown fine sand that has been reworked by wind. Between the dunes are small, concave blowout areas that have soil material similar to that of the lower layers of Kermit and Pyote soils. Each time that strong winds cause a sandstorm, the dunes change in position and shape, but they remain oriented with the prevailing southwesterly winds.

Dune land is not suitable for cultivation, and it provides little grazing for livestock. The only vegetation is a few scattered plants of Havard oak, sand sage, and grasses.

This land type is mapped only in an association with Kermit soils.

Gila Series

The Gila series consists of deep, calcareous loamy soils. These soils formed in recently deposited, alluvial, stratified sediment that is high in lime and salts. The surface is smooth, and slopes are less than 1 percent.

In a representative profile, the surface layer is brown fine sandy loam that is about 16 inches thick and contains fine masses of salts. Below the surface layer, and extending to a depth of 44 inches, is light yellowish-brown fine sandy loam stratified with alternate bands of silty clay loam 1/16 to 1/8 inch thick.

The Gila soils are well drained. They are moderately permeable and have moderate to high salinity. These soils have not been flooded more than once in the past 25 years.

Gila soils are used mostly for irrigated crops.

Representative profile of Gila fine sandy loam in a cultivated field 300 feet northwest of a roadside park, 1.2 miles west of the intersection of U.S. Highway 80 and Farm Road 516 in Barstow:

Ap—0 to 16 inches, brown (10YR 5/3) fine sandy loam, dark brown (10YR 3/3) moist; weak, medium, prismatic structure; slightly hard, very friable, slightly sticky; few fine roots; few fine masses of calcium sulfate and other salts; saline; calcareous, moderately alkaline; abrupt, smooth boundary.

C—16 to 44 inches, light yellowish-brown (10YR 6/4) fine sandy loam, yellowish brown (10YR 5/4) moist; single grained (structureless); soft, very friable, slightly sticky; few alternate bands of silty clay loam 1/16 to 1/8 inch thick that have distinct bedding planes; few fine masses, threads, and films of calcium sulfate and other salts; saline; calcareous, moderately alkaline.

The thickness of the A horizon is 8 to 16 inches. The A and C horizons are light yellowish brown, brown, light brown, or reddish brown. The 10- to 40-inch soil section has a texture of fine sandy loam and contains thin strata of clay, clay loam, silty clay loam, and silt loam. The sediments below a depth of 40 inches range from fine sandy loam to loam and are stratified with other textures. The electrical conductivity of the saturation extract of the soil ranges from 4 to 15 millimhos per centimeter.

Gila fine sandy loam (Gf).—This soil is in long, oval or irregular areas 8 to 45 acres in size.

Included with this soil in mapping are small, circular areas or long, narrow bands of Patrole or Harkey soils 2 to 8 acres in size. Also included are small, oval areas of Toyah soils 2 to 6 acres in size.

This soil is used mainly for irrigated crops. It is suitable for small grain, sorghum, and vegetables. Alfalfa and cotton are the major crops.

The buildup of toxic salts in this soil is a concern if irrigation water of poor quality is used. The salts cause crusting that makes it difficult for seedlings to emerge. Salinity can be reduced by leaching with extra quantities of irrigation water of good quality. This soil responds to fertilizer and irrigation. Capability unit VIIs-4 (dry-land); Capability unit IIs-9 (irrigated); Salty range site.

Harkey Series

The Harkey series consists of deep, calcareous loamy soils. These soils formed in recently deposited, friable, loamy sediment that is high in lime and salts. The surface is nearly level and smooth, and slopes are less than 1 percent.

In a representative profile, the surface layer is brown, stratified loam about 16 inches thick. Below this, and extending to a depth of 42 inches, is light-brown silt loam stratified with lenses of clay 1/16 to 1/2 inch thick. The next layer, to a depth of 56 inches, is reddish-brown clay that contains many masses of gypsum and other salts (fig. 2).

These soils are well drained. Runoff is medium, and permeability is moderate. These soils are moderately high to very high in salinity. They have been flooded in the past, but not more than once in the past 25 years.

Harkey soils are used mostly for irrigated crops. Representative profile of Harkey loam in native range 1.2 miles south of an unimproved road 4 miles southeast of Barstow on Farm Road 516:

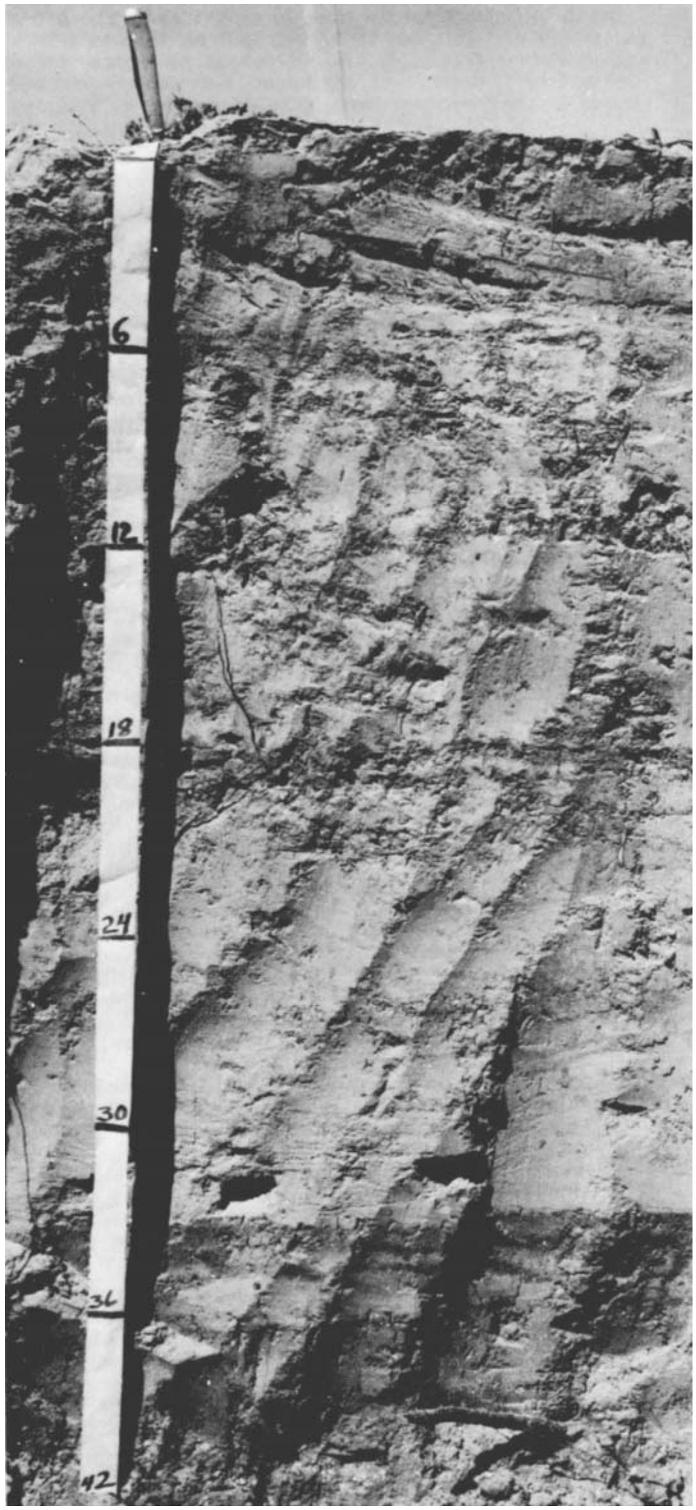

Figure 2.—Profile of Harkey loam.

A1—0 to 16 inches, brown (7.5YR 5/4) loam, brown (7.5YR 4/4) moist; weak, medium, subangular blocky structure; soft, very friable, slightly sticky; common line roots, tubes, and pores; stratified with lenses of clay 1/16 to 1/8 inch thick, which are between strata of fine sandy loam 1 to 3 inches thick; Bedding planes evident; saline; calcareous, moderately alkaline; clear, wavy boundary.

C1—16 to 42 inches, light-brown (7.5YR 6/4) silt loam, brown (7.5YR 5/4) moist; massive (structureless); hard, friable, slightly sticky; few fine roots; stratified with lenses of clay 1/16 to 1/2 inch thick; bedding planes distinct; saline; calcareous, moderately alkaline; clear, wavy boundary.

C2—42 to 56 inches, reddish-brown (5YR 5/4) clay, reddish brown (5YR 4/4) moist; massive (structureless); hard, firm, sticky and plastic; many threads, films, and medium masses of gypsum and other salts; saline; calcareous, moderately alkaline.

Depth to clay ranges from 40 to 48 inches. The A horizon is 6 to 18 inches thick and is light reddish brown or brown. The electrical conductivity of the saturation extract of the soil ranges from 4 to 32 millimhos per centimeter.

Harkey loam (Ha).—This soil is in long, narrow areas or in oval areas 8 to 25 acres in size along the Pecos River. Slopes are less than 1 percent.

Included with this soil in mapping are areas of Gila and Patrole soils that are up to 2 acres in size and generally oval in shape.

Most areas of this soil are used for irrigated crops. Maintenance of tilth, organic-matter content, and leaching of toxic salts are the main concerns of management on this soil. Salinity can be controlled by careful leaching. Applying excess irrigation water can create a perched water table. A drainage system may be necessary to successfully irrigate this soil. Only irrigation water of good quality should be used. Land leveling is necessary to obtain better distribution of irrigation water. Lining irrigation ditches helps to reduce water loss. Leaching of toxic salts helps to control salinity. This soil responds to fertilization. Capability unit VIs-2 (dryland); Capability unit IVs-6 (irrigated); Salty range site.

Hodgins Series

The Hodgins series consists of deep, calcareous loamy soils. These soils formed in calcareous sediment on outwash plains, old terraces, or alluvial fans. The surface is plane to slightly concave, and slopes are less than 1 percent.

In a representative profile, the surface layer is brown clay loam about 10 inches thick. Below this, and extending to a depth of 41 inches, is yellowish-red clay loam that contains fine masses of gypsum and other salts. The next layer, to a depth of 48 inches, is pink clay that is 25 to 35 percent soft masses, threads, and films of calcium carbonate and gypsum. It is underlain to a depth of 60 inches by reddish-brown clay that is 15 to 25 percent soft masses of calcium carbonate and gypsum.

The Hodgins soils are well drained. Runoff is slow, and permeability is moderate. These soils are high in salinity.

Most areas of these soils are used for crops. A few areas are in native range.

Representative profile of Hodgins clay loam in irrigated pasture 150 feet southeast of the intersection of Farm Roads 11 and 871, 3.1 miles southeast of Grandfalls on Farm Road 11:

Ap—0 to 10 inches, brown (7.5YR 5/4) clay loam, dark brown (7.5YR 3/2) moist; weak, fine and medium, subangular blocky structure; slightly hard, very friable, slightly sticky; few fine roots; few fine and medium masses, threads, and films of calcium carbonate and calcium sulfate; saline; calcareous, moderately alkaline; abrupt, smooth boundary.

B—10 to 41 inches, yellowish-red (5YR 5/6) clay loam, yellowish red (5YR 4/6) moist; weak, coarse, prismatic structure and weak, medium, subangular blocky structure; hard, very friable, slightly sticky; few fine masses of calcium sulfate and calcium carbonate; saline; calcareous, moderately alkaline; clear, smooth boundary.

C1cacs—41 to 48 inches, pink (5YR 7/4) clay, light reddish brown (5YR 6/4) moist; massive (structureless); slightly hard, very friable, slightly sticky; estimated 25 to 35 percent, by volume, soft masses, threads, and films of calcium carbonate and calcium sulfate; saline; calcareous, moderately alkaline; diffuse, smooth boundary.

C2cacs—48 to 60 inches, reddish-brown (5YR 5/4) clay, reddish brown (5YR 4/4) moist; massive (structureless); slightly hard, very friable, slightly sticky; estimated 15 to 25 percent calcium carbonate and calcium sulfate in soft masses; saline; calcareous, moderately alkaline.

The A horizon is brown, light brown, or pale brown. The texture of the soil at a depth of 10 to 40 inches is clay loam that ranges from an estimated 27 percent clay to 35 percent clay. The B horizon is yellowish red, light brown, or pale brown. The C1cacs horizon is at a depth between 40 and 70 inches. It is yellowish red or pink. The calcium carbonate content ranges from an estimated 5 percent to 35 percent. The gypsum ranges from a soft, powdery earth to crystals up to 1/8 inch in size. The calcium carbonate and calcium sulfate in the C2 horizon make up 15 to 25 percent of the mass. The electrical conductivity of the saturation extract of the soil ranges from 8 to 15 millimhos per centimeter.

The soils of Ward County named for this series are out-side the range of the series, because the B and C horizons are slightly redder. This difference does not alter their usefulness and behavior.

Hodgins clay loam (Ho).—This soil is in circular or irregularly shaped areas that range from 60 to 1,200 acres in size. The areas are nearly level and have slopes of less than 1 percent.

Included with this soil in mapping are oval areas of Monahans soils 1 to 3 acres in size.

This soil is calcareous and is high in salinity. Leaching of toxic salts with irrigation water of good quality helps to control salinity. Crusting on this soil makes it difficult for seedlings to emerge. Management practices that include crops that provide cover and a large amount of crop residue to improve the soil tilth are needed. Land leveling should be used to provide even distribution of water. Ditch lining is also needed to help pre-vent loss of irrigation water. Most crops grown on this soil respond to Irrigation and fertilization. Capability unit VIc-7 (dryland): Capability unit IIs-7 (irrigated); Deep Upland range site.

Ima Series

The Ima series consists of deep, calcareous loamy soils. These soils are on alluvial fans or old terraces adjacent to the Pecos River flood plain. They formed in loamy, mixed sediment. The surface is plane, and slopes range from 0 to 3 percent.

In a representative profile, the surface layer is brown fine sandy loam about 10 inches thick. Below this is reddish-yellow, very friable, calcareous fine sandy loam that contains a few small igneous pebbles and calcium carbonate fragments and extends to a depth of about 44 inches. The next layer, to a depth of 72 inches, is light-brown fine sandy loam that contains soft masses, threads, and films of calcium carbonate and a few waterworn igneous pebbles.

Ima soils are well drained. Runoff is slight, and permeability is moderately rapid. These soils are high in salinity.

Most areas of these soils are used for crops. A few areas are in native range.

Representative profile of Ima fine sandy loam, 0 to 3 percent slopes, in an abandoned field 100 feet south of U.S. Highway 80, 1.1 miles east of the intersection of Farm Road 516 and U.S. Highway 80 in Barstow:

Ap—0 to 10 inches, brown (10YR 5/3) fine sandy loam, brown (10YR 4/3) moist; weak, medium, subangular blocky structure; slightly hard, very friable, slightly sticky; common fine roots; few fine pores; saline; calcareous, moderately alkaline; abrupt, smooth boundary.

B2—10 to 44 inches, reddish-yellow (7.5YR 6/6) fine sandy loam, strong brown (7.5YR 5/6) moist; weak, coarse, prismatic structure and weak, medium, subangular blocky structure; slightly hard, very friable, slightly sticky; few, fine and medium, igneous pebbles and calcium carbonate fragments; saline; calcareous, moderately alkaline; diffuse boundary.

C1ca—44 to 56 inches, light-brown (7.5YR 6/4) fine sandy loam, brown (7.5YR 5/4) moist; massive (structureless); slightly hard, very friable, slightly sticky; fine calcium carbonate threads and films, common fine calcium carbonate fragments; estimated 10 to 15 percent, by volume, calcium carbonate; saline; calcareous, moderately alkaline; clear, smooth boundary.

C2—56 to 72 inches, light-brown (7.5YR 6/4) fine sandy loam, brown (7.5YR 5/4) moist; massive (structureless); slightly hard, very friable, slightly sticky; few threads and small masses of calcium carbonate; less lime than in horizon above; few, rounded, water-worn, igneous pebbles; calcareous, moderately alkaline.

The A horizon ranges from 8 to 14 inches in thickness. It is brown or light yellowish brown. The clay content at a depth of 10 to 40 inches ranges from an estimated 12 percent to 18 percent. The B2 horizon ranges from 20 to 40 inches in thickness. It is reddish brown, reddish yellow, or light yellowish brown. The electrical conductivity of the saturation extract of the soil ranges from 8 to 11 millimhos per centimeter.

Ima fine sandy loam, 0 to 3 percent slopes (Im).—This soil is in long, oval areas ranging from 30 to 120 acres in size.

Included with this soil in mapping are small, irregular areas of Monahans soils 8 to 12 acres in size. Included also are a few, small, circular areas of a soil that is similar to this Ima soil but is 15 to 25 percent gravel. These areas are less than 2 acres in size.

The major crops grown on this soil are alfalfa and cotton. Other suitable crops are grain sorghum, grasses, small grain, and vegetables.

The hazard of soil blowing is moderate on this soil. This soil is suitable for cultivation where sufficient quantities of irrigation water of good quality are available. Management is needed to control soil blowing and to keep good tilth. Leaching of toxic salts with irrigation water of good quality helps to control salinity. Crops that produce cover and a large amount of residue should be planted. Land leveling is needed for even distribution of irrigation water. Ditch lining is also needed to reduce losses of irrigation water. Capability unit VIe-1 (dryland); Capability unit IIe-1 (irrigated); Sandy Loam range site.

Kermit Series

The Kermit series consists of deep, noncalcareous, sandy soils. These soils formed in noncalcareous, deep sandy material of mixed origin that has been reworked by wind.

In a representative profile, the surface layer is very pale brown, neutral fine sand about 12 inches thick. Below this is very pale brown, neutral, loose fine sand about 48 inches thick. The underlying material, extending to a depth of 75 inches, is light-yellowish-brown fine sand.

These soils are excessively drained. Runoff is very slow, and permeability is very rapid. The hazard of soil blowing is severe. These soils are free of salts or alkali.

Kermit soils are used mostly for range and recreation.

Representative profile of Kermit fine sand in an area of Kermit-Dune land association, hummocky, in native range 100 feet south of U.S. Highway 80, 2 miles east of intersection with Texas Highway 18 in Monahans:

A1—0 to 12 inches, very pale brown (10YR 7/4) fine sand, light yellowish brown (10YR 6/4) moist; single grained (structureless); loose, nonsticky; few fine roots; few black sand grains; neutral; diffuse, smooth boundary.

C1—12 to 60 inches, very pale brown (10YR 7/4) fine sand, light yellowish brown (10YR 6/4) moist; single grained (structureless); loose, nonsticky; few fine and coarse roots; neutral; diffuse, smooth boundary.

C2—60 to 75 inches, light yellowish-brown (10YR 6/4) fine sand, yellowish brown (10YR 5/4) moist; single grained (structureless); loose, nonsticky; weakly coherent with what appears to be an organic adhesive; neutral.

The A1 horizon is very pale brown or brown. The C horizon is brown, yellow, light yellowish brown, or very pale brown. The combined amount of silt and clay between depths of 10 to 40 inches ranges from 4 percent to less than 10 percent. The sand grains are white, clear, or opaque, or are yellowish and reddish brown. Sand grains generally are round and smooth, but a few have sharp, irregular edges.

The soils named for this series are outside the range of the series, because they receive about 12 inches of rainfall and their minerology is marginal to mixed. These differences do not alter their usefulness and behavior.

Kermit-Dune land association, hummocky (KD).—This association is in broad areas on uplands. The areas are gently undulating to hummocky and range from 400 to 24,000 acres in size. They are irregular in shape.

Kermit fine sand makes up an average of 55 percent of the mapped areas, and Dune land an average of 45 percent.

The individual dunes generally range from 10 to 160 acres in size. In one area, a series of dunes occupies 3,000 acres. This is the site of Monahan Sandhills State Park. The dunes range from 16 to 25 feet in height and are long and narrow (fig. 3).

Figure 3.—Area of Kermit-Dune land association, hummocky.

Included in this mapping unit are areas of Pyote soils, 20 to 40 acres in size that occupy slightly concave, irregularly shaped interdune areas.

This association is used mostly for range and recreation. Capability unit VIIe-2 (dryland); Deep Sand range site.

Kinco Series

The Kinco series consists of deep, calcareous loamy soils. These soils occupy eolian plains or closed, shallow basins. Kinco soils formed in calcareous, unconsolidated loamy sediment of eolian or alluvial origin. The surface is plane to concave. Slopes range from less than 1 percent to 3 percent.

In a representative profile, the surface layer is pale-brown, calcareous fine sandy loam 8 inches thick. Below the surface layer and extending to a depth of 32 inches, is very pale brown, calcareous fine sandy loam. The next lower layer is reddish-yellow, calcareous loam that is about 20 percent threads, soft masses, and concretions of calcium carbonate. Below this, to a depth of 66 inches, is pink, calcareous loam that is 5 percent calcium carbonate.

These soils are well drained and moderately rapidly permeable. They are very low in salinity.

Representative profile of Kinco fine sandy loam, 0 to 3 percent slopes, in native range 150 yards west of an unimproved ranch road, 100 yards south of a boundary fence; then 1.4 miles south to junction of ranch road and U.S. Highway 80, which point is 7.4 miles west of the intersection of U.S. Highway 80 and Texas Highway 115 in Pyote:

A1—0 to 8 inches, pale-brown (10YR 6/3) fine sandy loam, brown (10YR 4/3) moist; weak, coarse, prismatic structure and weak, fine, granular structure; slightly hard, very friable, slightly sticky; common roots; few pores and insect burrows; few, very fine, weakly cemented calcium carbonate concretions; calcareous, moderately alkaline; gradual, smooth boundary.

B2—8 to 32 inches, very pale brown (10YR 7/3) fine sandy loam, brown (10YR 5/3) moist; weak, coarse, prismatic structure and weak, fine, subangular blocky structure; slightly hard, friable, slightly sticky; few fine roots; few pores and insect burrows; few, fine, weakly cemented concretions and fine films and threads of calcium carbonate; calcareous, moderately alkaline; diffuse, smooth boundary.

C1ca—32 to 52 inches, reddish-yellow (7.5YR 6/6) loam, yellowish red (5YR 4/6) moist; massive (structureless); slightly hard, friable, slightly sticky; contains 20 percent, by volume, weakly cemented concretions, soft masses, threads, and films of calcium carbonate; few fine pores; few igneous pebbles; calcareous, moderately alkaline; diffuse, wavy boundary.

C2—52 to 66 inches, pink (7.5YR 7/4) loam, brown (7.5YR 5/4) moist; massive (structureless); slightly hard, friable, sticky; contains about 5 percent, by volume, calcium carbonate; calcareous, moderately alkaline.

The A1 horizon ranges from 6 to 15 inches in thickness. It is pale brown, brown, or light yellowish brown. The B2 horizon is brown or very pale brown. The Cca horizon is pink, very pale brown, or reddish yellow. The calcium carbonate content ranges from an estimated 15 percent to 35 percent in the form of soft, masses, threads, and cemented rounded fragments. The C2 horizon is pink, light brown, or very pale brown. The electrical conductivity of the saturation extract of the soil ranges from 1 to 3 millimhos per centimeter.

Kinco fine sandy loam, 0 to 3 percent slopes (Kc).—Areas of this soil range from 100 to 2,200 acres in size and are irregular or oval in shape. This nearly level to gently sloping soil occupies broad areas. The slopes are plane to convex.

Included with this soil in mapping are areas of soils similar to this Kinco soil but having a layer of calcium carbonate accumulation at a depth greater than 40 inches. These areas range from 2 to 40 acres in size and are oblong or circular. Also included are circular or oblong areas of soils, 15 to 25 acres in size, that have a loamy fine sand surface layer that is less than 10 inches thick.

Most of this soil is used for range. Small areas are used for building sites within the city limits of Monahans. Capability unit VIe-1 (dryland); Capability unit IIIc-10 (irrigated); Sandy Loam range site.

Los Tanos Series

The Los Tanos series consists of moderately deep, calcareous, loamy soils on eroded upland plains. These soils formed in loamy sediment derived from Santa Rosa sandstone of Triassic age. Slopes are 1 to 5 percent. The surface is plane to convex.

In a representative profile, the surface layer is red fine sandy loam 6 inches thick that is 5 to 15 percent, by volume, caliche fragments. Below this is red fine sandy loam about 22 inches thick. The next layer, to a depth of about 35 inches, is thick, cemented, platy sandstone that has a distinct coating of calcium carbonate. The sandstone ranges from 1/8 inch to 6 inches in thickness and measures as much as 18 inches across the long axis.

These soils are well drained. Runoff is medium, and permeability is rapid. These soils are free of salts and alkali.

These soils are used mostly for range.

Los Tanos soils are mapped only in an association with Courthouse soils.

Representative profile of a Los Tanos fine sandy loam in an area of Los Tanos-Courthouse association in native range, 0.7 mile west of a range trail below a low escarpment and 7 miles south of U.S. Highway 80 (Interstate 20), which point is 7.4 miles east of intersection of Farm Road 516 and U.S. Highway 80 in Barstow:

A1—0 to 6 inches, red (2.5YR 5/6) fine sandy loam, dark red (2.5YR 3/6) moist; weak, fine, subangular blocky and granular structure; soft, very friable, slightly sticky; few fine and medium roots; estimated 5 to 15 percent, by volume, fragments of calcium carbonate; few medium igneous pebbles; mildly alkaline; clear, smooth boundary.

B2—6 to 28 inches, red (2.5YR 4/6) fine sandy loam, dark red (2.5YR 3/6) moist; weak, prismatic and granular structure; slightly hard, very friable, slightly sticky; common fine and few medium roots; common fine calcium carbonate fragments and few very fine calcium carbonate threads; common insect and worm casts and burrows; mildly alkaline; abrupt, smooth boundary.

Cca—28 to 33 inches, red (2.5YR 4/6), cemented, platy sand-stone; plates are 1/8 to 1/4 inch thick and coated with distinct films of calcium carbonate; calcareous, moderately alkaline; abrupt, smooth boundary.

R—33 to 35 inches, strongly cemented sandstone in plates up to 18 inches across and more than 6 inches thick; calcium carbonate coatings on the upper surfaces of plates and in crevices between them.

These soils are red or reddish yellow. The A horizon is 4 to 8 inches thick. Cemented sandstone is at a depth of 20 to 40 inches. It ranges from weakly cemented to indurated and is variable in thickness. In some places the sandstone is in thin, easily broken plates, and in others it is in blocks 3 feet on a side.

The soils of Ward County named for this series are outside the range of the series because they are slightly more clayey and redder. These differences do not affect their usefulness and behavior.

Los Tanos-Courthouse association (LT).—Areas of this association range from 320 to 670 acres in size and are long and oval or irregular in shape. Slopes are 1 to 12 percent. Los Tanos fine sandy loam makes up 50 to 60 percent of this mapping unit, and Courthouse fine sandy loam makes up 25 to 35 percent (fig. 4). Sandstone outcrops ranging from a few feet in diameter to 10 acres in size makeup from 5 to 25 percent of the mapping unit.

Figure 4.—Area of Los Tanos-Courthouse association.

Courthouse soils have slopes of up to 12 percent and occupy the steeper part of a south-facing escarpment 25 to 50 feet high. Los Tanos soils have slopes of 1 to 5 percent and occupy the less sloping areas below the escarpment.

Included with these soils in mapping are long or oval areas of Delnorte and Upton soils 1 to 3 acres in size. Also included on low ridges are crescent-shaped areas of Ima soils 1 to 5 acres in size.

The soils in this mapping unit are used for range. Capability unit VIIs-1 (dryland); Gravelly range site.

McCarran Series

The McCarran series consists of calcareous and gypseous loamy soils that are shallow to very shallow over gypsiferous earth. These soils formed in loamy sediment that is high in gypsum. They are nearly level and are in broad, convex areas on uplands.

In a representative profile, the upper 4 inches of the surface layer is pale-brown, calcareous loam. The next 6 inches is very pale brown, calcareous silt loam. The underlying material, extending to a depth of 15 inches, is white gypsic earth of loam texture.

These soils are moderately well drained. Surface runoff is medium, and permeability is moderate. They have low to moderate salinity.

McCarran soils are used mainly for range. A few small areas are cultivated with surrounding deeper soils.

Representative profile of a McCarran loam in an area of McCarran soils, nearly level, in range 100 yards west of an unimproved ranch road and 0.65 mile southeast of its intersection with Farm Road 1927, 2.4 miles south of Interstate Highway 20 at Pyote:

A11—0 to 4 inches, pale-brown (10YR 6/3) loam, brown (10YR 4/3) moist; weak, fine and medium, subangular blocky structure; soft, very friable, slightly sticky; few fine and medium roots; common fine tubes and pores; slight crusting and lichens on the surface; many very fine threads and films of calcium carbonate; few medium insect casts and burrows; calcareous, moderately alkaline; abrupt, smooth boundary.

A12—4 to 10 inches, very pale brown (10YR 7/3) silt loam, brown (10YR 5/3) moist; weak, medium, prismatic structure and weak, fine, subangular blocky structure; soft, very friable, slightly sticky; many fine and medium insect and worm casts and burrows; many very fine threads and films and few very fine concretions of calcium carbonate; saline; calcareous, moderately alkaline; abrupt, wavy boundary.

Ccs—10 to 15 inches. white (10YR 8/2) gypsic earth of loam texture, light gray (10YR 7/2) moist; massive; slightly hard, friable, slightly sticky; estimated 85 to 95 percent, by volume, gypsum; estimated 5 to 15 percent, by volume, soft masses and threads of calcium carbonate; weakly cemented in upper 2 inches.

Depth to the gypsic layer ranges from 3 to 18 inches. The A11 and A12 horizons are loam or silt loam. The clay content ranges from an estimated 18 percent to 25 percent. The A11 and A12 horizons are light brown, very pale brown, or pale brown. The calcium carbonate ranges from an estimated 5 percent to 40 percent. The upper 2 inches is weakly cemented and has a hardness of less than 2.5 on Mohs' scale. The electrical conductivity of the saturation extract ranges from 2 to 6 millimhos per centimeter.

McCarran soils, nearly level (MC).—These soils are on uplands. Areas are irregular or oblong and range from 200 to 16,000 acres in size. Slopes are 0 to 1 percent. This undifferentiated group consists of about 65 percent McCarran soils and about 35 percent gypsum outcrops.

Included with these soils in mapping are small areas of Delnorte soils, 2 to 10 acres in size, on knobs or hilltops, and small areas of Monahans soils, 1 to 5 acres in size, in circular, slightly concave areas. A few areas of McCarran soils that have slopes up to 3 percent are also included.

Most areas of these soils are native range. Because rooting depth is shallow, these soils are not suitable for cultivation. Capability unit VIIs-5 (dryland); Gyp range site.

Monahans Series

The Monahans series consists of deep, calcareous, loamy soils on uplands. These soils formed in calcareous old alluvium and basin deposits derived from limestone and igneous mountains. The surface is plane, and slopes are 0 to 2 percent.

In a representative profile, the surface layer is pale-brown fine sandy loam about 8 inches thick. Below this, and extending to a depth of 28 inches, is friable, light-brown sandy clay loam. The next lower layer, to a depth of 60 inches is pink, structureless, friable sandy clay loam that contains soft and cemented masses of calcium carbonate and gypsum.

These soils are well drained. Runoff is slow to very slow, and permeability is moderate. These soils have moderate to high salinity.

Monahans soils are used mostly for range.

Representative profile of Monahans fine sandy loam, 0 to 2 percent slopes, in a cultivated field 100 feet east of a field road, from a point 0.15 mile northwest of a gravel road, from a point 0.45 mile west of its intersection with Farm Road 516, 5.3 miles northwest of its intersection with old U.S. Highway 80 in Barstow:

Ap—0 to 8 inches, pale-brown (10YR 6/3) fine sandy loam, brown (10YR 4/3) moist; weak, fine, subangular blocky structure and weak, fine, granular structure; slightly hard, very friable, slightly sticky; many roots; many fine and medium insect casts and burrows; common tubular pores; few, fine, weakly cemented concretions and soft masses of calcium carbonate; saline; calcareous, moderately alkaline; abrupt, smooth boundary.

B—8 to 28 inches, light-brown (7.5YR 6/4) sandy clay loam, brown (7.5YR 4/4) moist; moderate, fine, subangular blocky structure; slightly hard, friable, sticky; few roots; common, fine, tubular pores; few insect casts and burrows; few, fine, soft masses of calcium carbonate, few fine gypsum crystals; few medium igneous pebbles; saline; calcareous, moderately alkaline; gradual, wavy boundary.

C1cacs—28 to 48 inches, pink (7.5YR 8/4) sandy clay loam, light brown (7.5YR 6/4) moist; massive (structureless); slightly hard, friable, sticky; about 15 percent of horizon, by volume, is gypsum crystals and calcium carbonate in the form of fine soft masses and weakly cemented concretions; saline; calcareous, moderately alkaline; diffuse, wavy boundary.

C2cacs—48 to 60 inches, pink (7.5YR 7/4) sandy clay loam, brown (7.5YR 5/4) moist; massive (structureless); slightly hard, friable, sticky; contains slightly less visible calcium carbonate and gypsum than horizon above; saline; calcareous, moderately alkaline.

The solum ranges from 14 to 36 inches in thickness. The A horizon is 4 to 12 inches thick. It is pale brown or brown. Structure is weak to moderate, fine or very fine, subangular blocky and granular. The B horizon is light brown, pale brown, or pink. The C horizon is about 10 to 20 percent visible calcium carbonate in the form of fine, weakly cemented concretions and soft masses, and about 5 to 15 percent visible gypsum crystals. The electrical conductivity of the saturation extract ranges from 5 to 12 millimhos per centimeter.

Monahans fine sandy loam, 0 to 2 percent slopes (Mo).—This soil is in areas 20 to 120 acres in size and irregular to oval in shape.

Included with this soil in mapping are small, circular areas of McCarran soils 2 to 10 acres in size. Kinco soils occupy oval or circular areas up to 10 acres in size. Also included are a few areas of soils, 2 to 6 acres in size, that are 3 to 12 percent gravel, by volume.

This soil is suitable for cultivation where sufficient irrigation water of good quality is available. Major crops grown are alfalfa and cotton (fig. 5). Grain sorghum, grasses, small grain, and vegetables are other suitable crops. Management is needed that maintains soil tilth and controls soil blowing. The hazard of soil blowing is moderate. Crops that produce cover and large amounts of residue should be planted. Land leveling is needed for even distribution of irrigation water. Ditch lining is needed to reduce losses of irrigation water. Capability unit VIe-1 (dryland); Capability unit IIe-1 (irrigated); Sandy Loam range site.

Figure 5.—Irrigated cotton on Monahans fine sandy loam, 0 to 2 percent slopes.

Patrole Series

The Patrole series consists of deep, calcareous, loamy soils on flood plains. These soils formed in recent stratified loamy alluvium that lies over clayey alluvium. The surface is plane and smooth, and slopes are less than 1 percent.

In a representative profile, the surface layer is light reddish-brown very fine sandy loam about 12 inches thick. Below this, to a depth of 30 inches, is reddish-brown, calcareous silt loam that contains thin strata of clay. The next layer, to a depth of 49 inches, is reddish-brown, calcareous clay that contains threads and elongated masses of gypsum and other salts. This layer also contains thin strata of clay loam and other textures (fig. 6).

These soils are moderately well drained. Runoff is slow, and permeability is moderately slow. Salinity is high to very high.

Representative profile of Patrole very fine sandy loam 1.2 miles southeast of an unimproved oilfield road, 4.1 miles southeast of the intersection of U.S. Highway 80 and Farm Road 516 in Barstow:

A1—0 to 12 inches, light reddish-brown (5YR 6/4) very fine sandy loam, reddish brown (5YR 4/4) moist; weak, fine, granular structure; slightly hard, friable, sticky; common fine roots; many fine and medium tubes and pores; few insect burrows; evident bedding planes; many threads and soft masses of calcium sulfate and other salts; many fine strata of silt loam; saline; calcareous, moderately alkaline; gradual, wavy boundary.

C1—12 to 30 inches, reddish-brown (5YR 5/4) silt loam, reddish brown (5YR 4/4) moist; massive (structureless); very hard, firm, sticky; few fine roots; common fine pores; evident bedding planes; many fine threads and soft masses of calcium sulfate and other salts; few strata of clay 1/4 to 1/2 inch thick; saline; calcareous, moderately alkaline; clear, wavy boundary.

C2—30 to 49 inches, reddish-brown (2.5YR 4/4) clay, dark reddish brown (2.5YR 3/4) moist; massive (structureless); extremely hard, extremely firm, very sticky and very plastic; many threads and elongated soft masses of calcium sulfate and other salts; few lenses of clay loam and other textures; few bedding planes; saline; calcareous, moderately alkaline.

Figure 6.—Profile of Patrole very fine sandy loam.

Depth to the clayey horizon ranges from 20 to 36 inches. The A horizon is 8 to 16 inches thick. It is reddish brown, light reddish brown, or pale brown. The C horizon is light brown or reddish brown silt loam to clay. The electrical conductivity of the saturation extract of the soil ranges from 8 to 16 millimhos per centimeter.

About one-fourth of the acreage of Patrole soils in this county is outside the range of the series because the upper 20 to 30 inches is less than 18 percent clay. This difference does not affect usefulness and behavior.

Patrole very fine sandy loam (Pa).—This soil is in long, narrow areas ranging from 20 to 60 acres in size. It is nearly level and has slopes of less than 1 percent.

This soil has been flooded in the past, but it has not been flooded more than once in the past 25 years.

Included with this soil in mapping are small, long, narrow areas of Gila soils 1 to 5 acres in size, and small areas of Harkey soils, 1 to 4 acres in size. These included areas occupy the same landscape as Patrole soils.

Most areas of this soil are used as native range. This soil is not suitable for continuous irrigation. The clay layer soon becomes saturated with irrigation water, and the resulting perched water table drowns the crops and increases the salinity of the soil. Capability unit VIIs-4 (dryland); Capability unit IVs-6 (irrigated); Salty range site.

Pecos Series

The Pecos series consists of deep, calcareous and saline, clayey soils. These soils are in depressional, formerly wet areas on the Pecos River flood plain. The Pecos soils formed in alluvium. The surface is plane to slightly concave, and slopes are less than 1 percent.

In a representative profile, the surface layer is dark grayish-brown, calcareous silty clay about 16 inches thick. Below this is grayish-brown silty clay about 8 inches thick that contains olive-yellow mottles. The next 12 inches is reddish-brown, calcareous clay. Below this is about 6 inches of reddish-brown silty clay that cracks when it dries. The next lower layer, extending to a depth of 56 inches, is reddish-brown, calcareous, massive clay that contains threads and soft masses of gypsum.

Internal drainage is slow. Runoff is slow to ponded, and permeability is very slow. These soils have high to very high salinity.

These soils are not suited to cultivation; they are saline and very slowly permeable. Some areas have been cultivated but are now mostly abandoned. These soils have been flooded in the past, but not more than once in the last 25 years.

Representative profile of Pecos silty clay in a cultivated field 100 feet northwest of an unimproved field road, then 0.3 mile northeast to canal No. 1, which point is 2.2 miles southeast of a paved county road going northeast from the Sullivan Bridge.

Ap—0 to 16 inches, dark-grayish-brown (10YR 4/2) silty clay, very dark grayish brown (10YR 3/2) moist; moderate, fine and medium, subangular blocky structure; very hard, very firm; few fine roots; common very fine tubes and pores; common fine threads and soft masses of calcium sulfate and other salts; few cracks 0.5 inch wide extend to lower boundary; saline; calcareous, moderately alkaline; abrupt, smooth boundary.

A12—16 to 24 inches, grayish-brown (10YR 5/2) silty clay, dark grayish brown (10YR 4/2) moist; common, medium, distinct mottles of olive yellow (2.5Y 6/6); weak, medium, subangular blocky structure; very hard, very firm, few fine roots; common fine threads and soft masses of calcium sulfate and other salts; cracks 0.5 inch wide extend to lower boundary; saline; calcareous, moderately alkaline; abrupt, wavy boundary.

C1—24 to 36 inches, reddish-brown (5YR 5/4) clay, reddish brown (2.5YR 3/4) moist; massive (structureless); extremely hard, very firm; many fine threads and soft masses of calcium sulfate and other salts; cracks 0.5 inch wide extend to lower boundary; saline; calcareous, moderately alkaline; abrupt, wavy boundary.

C2—36 to 42 inches, reddish-brown (5YR 5/3) silty clay, reddish brown (5YR 4/3) moist; massive structureless); very hard, very firm; many very fine threads and soft masses of calcium sulfate and other salts; few, fine, black stains along old bedding planes; few cracks 0.5 inch wide; saline; calcareous, moderately alkaline; clear, wavy boundary.

C3—42 to 56, reddish-brown (2.5YR 4/4) clay, dark reddish brown 2.5YR 3/4) moist; massive (structureless); extremely hard, extremely firm; few cracks 0.5 inch wide; many threads and soft masses of calcium sulfate; saline; calcareous, moderately alkaline.

The clay content between depths of 10 and 40 inches ranges from 35 to 60 percent. The A horizon is dark grayish brown or grayish brown. The C horizon is reddish brown or grayish brown. Mottles range from faint to distinct. The electrical conductivity of the saturation extract of the soil ranges from 8 to 32 millimhos per centimeter.

Pecos silty clay (Pe).—This soil is on a nearly level flood plain in areas that range from 25 to 1,000 acres in size. These areas are generally long and oval.

Included with this soil in mapping are areas of Arno, Toyah, and Gila soils. These inclusions are circular to lone and oval and range from 1 to 8 acres in size.

This soil is used for range. It is not suitable for most crops, because it is saline. It is very permeable. The concentration of salt is above the tolerance level of most crops. Most of the formerly cultivated areas were leveled for irrigation. These are now abandoned. Capability unit VIIs-4 (dryland); Salty range site.

Pyote Series

The Pyote series consists of deep, noncalcareous, sandy soils. Those are gently undulating soils on upland plains. They formed in sandy unconsolidated sediment of eolian or alluvial origin. The surface is plane to undulating.

In a representative profile, the upper 12 inches of the surface layer is yellowish-red, noncalcareous loamy fine sand. Below this is reddish-brown, noncalcareous loamy fine sand 22 inches thick. The next layer, to a depth of 50 inches, is reddish-brown, noncalcareous fine sandy loam. Yellowish-red fine sandy loam extends to a depth of 62 inches. The next lower layer, which reaches to a depth of 76 inches, is pink, calcareous fine sandy loam that contains threads, films, and soft masses of calcium carbonate.

Pyote soils are well drained. Runoff is none to very slow, and permeability is moderately rapid. These soils are free of salts and alkali.

Representative profile of a Pyote loamy fine sand in an area of Pyote soils, undulating, in native range 200 feet west of Spur 65 and 0.2 mile north of Interstate 20 at Wickett:

A11—0 to 12 inches, yellowish-red (5YR 5/6) loamy fine sand, yellowish red (5YR 4/6) moist; single grained (structureless); loose, nonsticky; common fine and few medium roots; mildy alkaline; gradual, smooth boundary.

A12—12 to 34 inches, reddish-brown (5YR 5/4) loamy fine sand, reddish brown (5YR 4/4) moist; single grained (structureless); loose, nonsticky; few fine and medium roots; some sand grains coated with what appears to be iron oxide; mildly alkaline; clear, smooth boundary.

B21t—34 to 50 inches, reddish-brown (5YR 5/4) fine sandy loam, yellowish red (5YR 4/6) moist; weak, coarse, prismatic structure breaking to weak, medium, subangular blocky structure; slightly hard, very friable, slightly sticky; few fine roots; clay coating and bridging of sand grains; many fine tubes and pores; mildly alkaline; clear, smooth boundary.

B22t—50 to 62 inches, yellowish-red (5YR 5/6) fine sandy loam, yellowish red (5YR 4/6) moist; weak, coarse, prismatic structure breaking to weak, medium, subangular blocky structure; slightly hard, very friable, slightly sticky; few fine roots; clay coatings on sand grains and some bridging of sand grains; calcareous, moderately alkaline; clear, wavy boundary.

C1ca—62 to 70 inches, pink (5YR 7/3) fine sandy loam, light reddish brown (5YR 6/3) moist; massive (structureless); slightly hard, very friable, slightly sticky; common fine threads and films of calcium carbonate and few soft masses of calcium carbonate; calcareous, moderately alkaline; gradual, wavy boundary.

C2—70 to 76 inches, pink (5YR 7/4) fine sandy loam, light reddish brown (5YR 6/4) moist; massive (structureless); slightly hard, very friable, slightly sticky; fine threads of calcium carbonate; calcareous, moderately alkaline.

The A horizon is reddish brown, yellowish red, reddish yellow, light reddish brown, or brown. It is loamy fine sand to fine sand. The Bt horizon is reddish brown, yellowish red, or reddish yellow. It is loam to fine sandy loam. The Bt horizon ranges from noncalcareous to calcareous in the matrix and is mildly alkaline to moderately alkaline in reaction. The C1ea horizon ranges from fine sandy loam to loamy fine sand.

Pyote soils, undulating (PY).—These soils occupy broad upland plains. Slopes are 1 to 4 percent. Most areas are irregular and range from 500 to 5,000 acres in size. However, one area is about 97,000 acres in size.

Included with this soil in mapping is a similar soil that has a lower layer of sandy clay loam, is in irregularly shaped areas that range from 4 to 18 acres in size, and has a smooth surface. Also included are oblong areas of Wickett and Sharvana soils 6 to 20 acres in size.

The hazard of soil blowing is severe on these soils.

Most areas of these soils are used for range, and a few small areas are used for housing and commercial development. A few small areas are used for irrigated crops. Capability unit VIe-2 (dryland); Capability unit IVe-1 (irrigated); Sandyland range site.

Sharvana Series

The Sharvana series consists of noncalcareous, loamy soils that are shallow to caliche. They occupy broad areas on uplands. The surface is plane to convex. Slopes range from 0 to 3 percent.

In a representative profile, the surface layer is brown, noncalcareous fine sandy loam about 4 inches thick. Below this is brown, noncalcareous fine sandy loam about 6 inches thick. The next lower layer, about 9 inches thick, is a pinkish white mass of cemented calcium carbonate that is about 25 percent brown fine sandy loam in the interstices. Below this layer, to a depth of 26 inches, is a thick bed of pink, indurated caliche plates that have a few igneous pebbles imbedded in the mass (fig. 7). This layer becomes softer with depth.

These soils are well drained. Runoff is medium, and permeability is moderate. These soils are free of salts and alkali. They are used mostly for range.

Representative profile of a Sharvana fine sandy loam in an area of Sharvana soils, nearly level, in native range, 150 feet east of a north-south graded ranch road, 0.6 mile south of U.S. Highway 80 (Interstate 20), which point is 7 miles west of the intersection of Farm Road 1927 and Interstate 20 in Pyote:

A1—0 to 4 inches, brown (7.5YR 5/4) fine sandy loam, dark brown (7.5YR 4/4) moist; single grained (structureless); soft, very friable, slightly sticky; few fine and common medium roots; few very fine calcium carbonate fragments, few igneous pebbles; mildly alkaline; clear, wavy boundary.

B2t—4 to 10 inches, brown (7.5YR 5/4) fine sandy loam, dark brown (7.5YR 4/4) moist; weak, coarse, prismatic structure and weak, fine, subangular blocky structure; slightly hard, very friable, slightly sticky; many fine and common medium roots; few insect casts and burrows; few fine and

Figure 7.—Profile of Sharvana soils, nearly level.

medium tubes and pores; few medium fragments of calcium carbonate 1/4 to 1/2 inch in diameter; lower 2 inches has common calcium carbonate fragments and few igneous pebbles; mildly alkaline; abrupt, wavy boundary.

C1cam—10 to 19 inches, pinkish-white (7.5YR 8/2) cemented mass of calcium carbonate concretions, pinkish gray (7.5YR 7/2) moist; in interstices is 25 percent, by volume, brown (7.5YR 5/4) fine sandy loam (calcareous), brown (7.5YR 4/4) moist; fragments are 4 to 6 inches in diameter and 1 to 3 inches in thickness; concretions in the cemented fragments range from 1/8 to 3/4 inch in size; few small igneous pebbles imbedded in the mass; few fine and medium roots in interstices; calcareous, moderately alkaline; clear, wavy boundary.

C2cam—19 to 26 inches, pink (7.5YR 8/4) indurated caliche, pink 7.5YR 7/4) moist; large plates 8 to 14 inches in diameter and 2 to 4 inches thick; large sand grains and small igneous pebbles imbedded in the mass; becomes softer with depth; calcareous, moderately alkaline.

The soil is noncalcareous to calcareous and is mildly alkaline. Depth ranges from 12 to 20 inches. The A horizon is reddish brown or brown. It is fine sandy loam to loamy fine sand. The B2t horizon is reddish brown or brown. The lower few inches of the B2t horizon contains from 10 to 20 percent, by volume, small, angular fragments of calcium carbonate. The C1ca horizon is weakly cemented to strongly cemented.

Sharvana soils, nearly level (SH).—These soils are in broad areas on uplands. The areas are irregular to long and oval in shape and range from 160 acres to more than 3,900 acres in size. The surface is smooth, and the slopes are convex. Slopes are from 0 to 1 percent. The soil material has been blown around individual grass and mesquite plants in small mounds. The mounds are 2 to 4 inches high and 10 inches to 4 feet in diameter.

Included with this soil in mapping are a few, small, irregularly shaped areas, 1 to 4 acres in size, of a similar soil that is more than 20 inches deep over caliche and has a surface layer of fine sandy loam. A few areas of Sharvana soils that have slopes of up to 4 percent are also included.

The hazard of soil blowing is moderate.

These soils are not suitable for cultivation because of shallow depth. The caliche under these soils is used as a source of road-building material. Most areas of these soils are used for range. Capability unit VIIs-1 (dryland); Shallow Sandy Loam range site.

Toyah Series

The Toyah series consists of deep, calcareous, loamy alluvial soils. These soils are on the flood plain. They formed in alluvium derived from soils that formed in material weathered from limestone and, possibly, sandstone. The surface is smooth and plane to convex, and slopes are less than 1 percent.

In a representative profile, the surface layer is dark grayish-brown clay loam that has threads of gypsum and other salts and is about 18 inches thick. Below the surface layer, to a depth of 44 inches, is pale-brown loam that is structureless and has mottles of light brownish gray.

Toyah soils are well drained. Runoff is medium, and permeability is moderate. These soils have a high salinity. They have been flooded in the past but not more than once in the past 25 years.

These soils are suited to cultivation if they are irrigated.

Representative profile of Toyah clay loam in an alfalfa field 100 yards north of an unimproved road, north of the railroad tracks at the western edge of Barstow, and 0.3 mile west of Farm Road 516:

Ap—0 to 18 inches, dark grayish-brown (10YR 4/2) clay loam, very dark grayish brown (10YR 3/2) moist; moderate, medium, subangular blocky structure; very hard, friable, very sticky; common fine and few medium alfalfa roots; common fine masses, threads, and films of calcium sulfate and other salts; saline; calcareous, moderately alkaline; abrupt, smooth boundary.

C—18 to 44 inches, pale-brown (10YR 6/3) loam, brown (10YR 5/3) moist; light brownish-gray (2.5YR 6/2) mottles; massive (structureless); slightly hard, very friable, slightly sticky; few fine and medium roots; distinct bedding planes; many fine and medium masses, threads, and films of calcium sulfate and other salts; few insect casts and burrows; saline; calcareous, moderately alkaline.

The A1 horizon is dark grayish brown or brown clay loam to loam. The C horizon is light brown, light yellowish brown, or pale brown. It is loam, sandy clay loam, or clay loam. The electrical conductivity of the saturation extract of the soil ranges from 11 to 14 millimhos per centimeter.

Toyah clay loam (To).—This soil is nearly level. Areas range from 20 to 140 acres in size and are irregular to long and oval in shape.

Included with this soil in mapping are a few, small, oval areas of Gila soils, 1 to 4 acres in size, and a few. small, circular areas of soils, 1 to 2 acres in size, that have a silty clay loam surface layer.

This soil is affected by salinity, and a crust forms when the surface soil dries. Leaching of toxic salts by use of irrigation water of good quality is necessary for successful crop production. This soil can be leached, and it responds to fertilizer.

This soil is used mostly for crops where irrigation water is available. The principal crops are alfalfa and cotton. Alfalfa both for hay and for seed is suited to this soil. Grain sorghum and vegetables also are suited. In places, land leveling is needed for better distribution of Irrigation water. Lining irrigation ditches helps to reduce water loss. Capability unit VIs-2 (dryland); Capability unit IIs-9 (irrigated); Salty range site.

Upton Series

The Upton series consists of calcareous, gravelly loamy soils that are very shallow or shallow to caliche. These soils formed in beds of caliche several feet thick. They occupy broad plains on uplands and terraces on foot slopes. The surface is gently undulating, and slopes range from 1 to 4 percent.

In a representative profile, the upper 18 inches is pale-brown, calcareous, gravelly loam that is 20 to 25 percent pebbles. The next layer, about 8 inches thick, is white, cemented caliche plates. Below this layer, to a depth of 46 inches, is a layer of pinkish-white, soft to weakly cemented caliche (fig. 8).

These soils are well drained. Surface runoff is medium, and permeability is moderate. These soils are free of salts and alkali. They are used mostly for range.

Representative profile of an Upton gravelly loam in an area of Upton gravelly soils, gently undulating, in range 200 feet northeast of a paved county road and 3.1 miles west of Royalty:

A1—0 to 3 inches, pale-brown (10YR 6/3) gravelly loam, brown (10YR 4/3) moist; weak, medium, subangular blocky structure; slightly hard, very friable, slightly sticky; few fine and medium roots and medium roots and tubes; slight surface crust 1/16 to 1/8 inch thick; estimated 20 to 25 percent gravel by volume; calcareous, moderately alkaline; clear, smooth boundary.

B2—3 to 18 inches, pale-brown (10YR 6/3) gravelly loam, brown (10YR 4/3) moist; weak, medium, subangular blocky structure; slightly hard, very friable, slightly sticky; few fine roots, estimated 20 to 25 percent gravel; calcareous, moderately alkaline; abrupt, smooth boundary.

C1cam—18 to 26 inches, white (10YR 8/2) cemented caliche; light gray (10YR 7/2) moist; distinct plates 1/4 to 1 inch thick and 3 to 6 inches along the long axis; calcareous, moderately alkaline; clear, smooth boundary.

C2—26 to 46 inches, pinkish-white (7.5YR 8/2), soft to weakly cemented caliche of fine sandy loam texture; structureless; calcareous, moderately alkaline.

Depth to caliche is 7 to 20 inches. In the entire profile, the volume of coarse fragments, generally caliche pebbles and fragments, ranges from 20 to 35 percent. The Al horizon is loam or fine sandy loam that has an estimated clay content between 18 to 26 percent. It is brown or pale brown. The B2 is pale brown or very pale brown. The Gleam horizon ranges from 8 to 20 inches in thickness. The C2 horizon is soft to weakly cemented caliche.

Upton gravelly soils, gently undulating (UP).—These soils have slopes of 1 to 4 percent. The areas range from 120 acres to 3,300 acres in size and are long and oval to irregular in shape. The surface layer ranges from gravelly loam to gravelly fine sandy loam.

Included with these soils in mapping are small, roughly circular areas of Sharvana soils 1 to 3 acres in size. Also included in a few mapped areas are small, circular areas of McCarran soils 2 to 5 acres in size.

The hazards of soil blowing and water erosion are moderate. During high-intensity rains, water runs off because of the surface crust.

Most areas of these soils are used for range and are not suitable for cultivation. Capability unit VIs-4 (dryland); Gravelly range site.

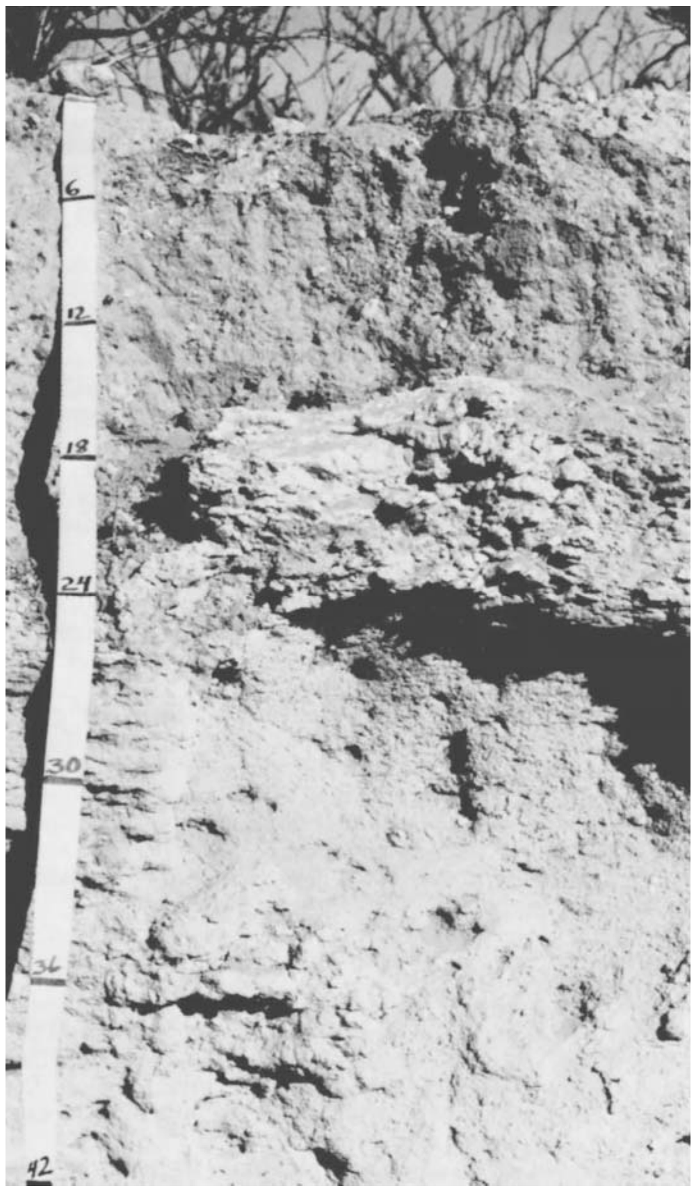

Figure 8.—Profile of Upton gravelly soils, gently undulating.

Verhalen Series

The Verhalen series consists of deep, noncalcareous, clayey soils on uplands. These soils formed in calcareous alluvium several feet thick. They are in enclosed basins or playas that are 3 to 10 feet below the surrounding upland soils. The surface is concave and has gilgai relief. Slopes are less than 1 percent.

In a representative profile, the surface layer is brown, noncalcareous clay about 10 inches thick. The next layer is reddish-brown clay about 27 inches thick. Below this, to a depth of about 41 inches, is reddish-brown clay that has few, very fine, soft masses of calcium carbonate and contains igneous pebbles.

These soils are moderately well drained. Runoff and permeability are slow. The soils are free of salts and alkali.

These soils are used for native range.

Representative profile of Verhalen clay in a playa in an area of range 300 yards east of a gravel county road located 7 miles north of Farm Road 516, which is 6 miles northwest of Barstow, or 1/2 mile south of the Loving-Ward County line:

A1—0 to 10 inches, brown (10YR 4/3) clay, dark brown (10YR 3/3) moist; moderate, fine and medium, blocky structure; very hard, very firm, very sticky and plastic; many fine and medium roots; few fine tubes and pores; mildly alkaline; clear, smooth boundary.

AC—10 to 37 inches, reddish-brown (5YR 5/3) clay, dark red-dish brown (5YR 3/3) moist; moderate, medium, blocky structure; very hard, very firm, very sticky and plastic; common fine roots; few fine tubes; few very fine fragments of calcium carbonate; shiny pressure faces and organic staining on ped faces; few faint slickensides; cracks 1/2 inch wide; calcareous, moderately alkaline; clear, smooth boundary.

C—37 to 41 inches, reddish-brown (5YR 5/4) clay, reddish brown (5YR 4/4) moist; consistence as in above horizon; massive (structureless); few, very fine, soft masses of calcium carbonate; common fine and medium igneous pebbles; calcareous, moderately alkaline.

The A horizon is reddish brown or brown. The AC horizon ranges from 27 to 36 inches in thickness. It is reddish brown or brown. The C horizon is at a depth of 27 to 48 inches.

Verhalen clay (VC).—This soil is in circular or oval areas 20 to 60 acres in size. It is nearly level and occurs in slightly concave, depressional basins or playas that have slopes of less than 1 percent (fig. 9).

Figure 9.—Area of Verhalen clay.

Included with this soil in mapping are small, circular or oval areas of a noncalcareous, reddish soil that has a clay loam surface layer and sandy clay loam lower layers. These areas are 2 to 4 acres in size.

This soil is used for range. It receives extra water during periods of high-intensity rainfall. Capability unit VIs-1 (dryland); Lakebed range site.

Wickett Series

The Wickett series consists of noncalcareous sandy and loamy soils that are moderately deep over indurated caliche. These soils are in broad areas on upland plains. They formed in a sandy and loamy eolian mantle over thick beds of caliche that is indurated in the upper part. Slopes range from 1 to 3 percent. The surface is plane to gently undulating.

In a representative profile, the surface layer is reddish-brown, noncalcareous loamy fine sand about 14 inches thick. The next layer is yellowish-red, noncalcareous fine sandy loam about 16 inches thick. The underlying material is weakly cemented to indurated caliche that extends to a depth of 38 inches.

Wickett soils are well drained. Runoff is very slow, and permeability is moderately rapid. These soils are free of salts and alkali.

Wickett soils are used mostly for range.

Representative profile of a Wickett loamy fine sand in an area of Wickett and Sharvana soils, gently undulating, in range, 30 feet east of an oilfield road and 2.3 miles north of the western edge of Wickett:

A1—0 to 14 inches, reddish-brown (5YR 5/4) loamy fine sand, reddish brown (5YR 4/4) moist; single grained (structureless); loose, nonsticky; common fine roots; mildly alkaline; clear, smooth boundary.

Bt—14 to 30 inches, yellowish-red (5YR 5/6) fine sandy loam, yellowish red (5YR 4/6) moist; weak, coarse, prismatic structure parting to weak, medium, subangular blocky structure; slightly hard; few roots; few clay films in pores; sand grains coated and bridged with clay; very friable, slightly sticky; mildly alkaline; abrupt, wavy boundary.

Ccam—30 to 38 inches, weakly cemented caliche in upper 2 inches over indurated platy caliche; platy caliche is laminar in the upper 2 inches.

The solum ranges from 20 to 40 inches in thickness over weakly cemented caliche. The A horizon is fine sandy loam to loamy fine sand 8 to 20 inches thick. It is reddish brown or brown. The Bt horizon is reddish-brown, yellowish-red, or brown loam to fine sandy loam. The caliche layer ranges from cemented to indurated and becomes softer as depth increases.

Wickett and Sharvana soils, gently undulating (WS).—These soils are in irregularly shaped areas up to 4,000 acres in size. Wickett loamy fine sand makes up 50 to 60 percent of the mapped areas and is in areas 100 to 3,600 acres in size. Sharvana loamy fine sand makes up 40 to 50 percent and is in areas 50 to 2,000 acres in size. Slopes are 1 to 3 percent.

The Wickett soils have the profile described as representative for the Wickett series.

The Sharvana soils have a reddish-brown loamy fine sand surface layer about 4 inches thick. The next layer is reddish-brown, very friable, noncalcareous fine sandy loam about 9 inches thick. Below this is about 3 inches of pinkish-white caliche fragments, and brown fine sandy loam is between the fragments. The next layer, at a depth of 16 inches, is pink caliche plates.

Included with these soils in mapping are small oval areas of Sharvana fine sandy loam 1 to 4 acres in size and circular areas of Pyote soils 1 to 8 acres in size.

Most areas of this mapping unit are used for range. A few small areas are used for cultivation under irrigation. Soil blowing is a severe hazard. The caliche under these soils is used as a source of road-building material. Capability unit VIe-2 (dryland); Capability unit IVe-1 (irrigated); Sandyland range site.

Wickett and Sharvana fine sandy loans, gently sloping (WT).—These soils are in areas 40 to 900 acres in size. Wickett fine sandy loam makes up 70 to 80 percent of the mapped areas and is in areas 30 to 750 acres in size. Sharvana fine sandy loam makes up 20 to 30 percent and is in areas 10 to 150 acres in size. Slopes are about 1 to 2 percent.

The Wickett soils have a reddish-brown, noncalcareous fine sandy loam surface layer about 8 inches thick. The next layer is yellowish-red, noncalcareous, very friable fine sandy loam 28 inches thick. A layer of indurated caliche is at a depth of 36 inches.

The Sharvana soils have a reddish-brown, noncalcareous fine sandy loam surface layer about 6 inches thick. The next layer is reddish-brown, friable, noncalcareous fine sandy loam 10 inches thick. A layer of pink, strongly cemented caliche is at a depth of 16 inches.

Included with these soils in mapping are long or oval areas of Pyote soils 12 to 18 acres in size.

Most areas of this mapping unit are used for range. A few small areas are used for irrigated crops. These soils respond to fertilization. Capability unit VIe-1 (dryland); Capability unit IIIc-10 (irrigated); Sandy Loam range site.

Use and Management of the Soils

This section discusses the use and management of the soils of the county for crops, as range, as wildlife habitat, and in engineering works.

Capability Grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are so used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to horticultural crops or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range or for engineering.

In the capability system, the kinds of soils are grouped at three levels: the capability class, subclass, and unit. These are discussed in the following paragraphs.

CAPABILITY CLASSES**,** the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

- Class I soils have few limitations that restrict their use. (None in Ward County.)
- Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.
- Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.
- Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, or wildlife habitat. (None in Ward County.)
Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture, range, or wildlife habitat.
Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture, range, or wildlife habitat.
Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife, water supply, or esthetic purposes. (None in Ward County.)

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter *e, w, s, or c,* to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c* shows that the chief limitation is climate that is too cold to too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by w, 8, and c, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, wildlife habitat, or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IVe-1 or VIe-2. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

Following are the descriptions of the capability units in Ward County. The information about soil use and management that commonly is presented in discussions of capability units is given in the mapping units in the section "Descriptions of the Soils." The capability units are not numbered consecutively in this survey, because not all of the capability units used in a multicounty area of Texas are in Ward County.

Capability unit IIe-1. Deep, nearly level to gently sloping, well-drained, loamy soils.
Capability unit IIs-7. Deep, nearly level, well-drained, loamy soils.
Capability unit IIs-9. Deep, nearly level, well-drained, loamy soils.
Capability unit IIIs-10. Shallow, moderately deep and deep, nearly level to gently sloping, well-drained, loamy soils.
Capability unit IVe-1. Shallow to deep, gently sloping, well-drained, sandy soils.
Capability unit IVs-6. Deep, nearly level, well drained to moderately well drained, loamy soils.
Capability unit VIc-7. Deep, nearly level, well-drained, loamy soils.
Capability unit VIe-1. Shallow to deep, nearly level to gently sloping, well-drained, loamy soils.

Capability unit VIe-2. Shallow to deep, gently sloping and undulating, well-drained, sandy soils.
Capability unit VIs-1. Deep, nearly level, slowly permeable, moderately well drained, clayey soils.
Capability unit VIs-2. Deep, nearly level, well-drained, loamy soils.
Capability unit VIs-4. Shallow to very shallow, gently undulating, well-drained, gravelly, loamy soils.
Capability unit VIIe-2. Deep, gently undulating to hummocky, well-drained, very rapidly permeable, sandy soils.
Capability unit VIIs-1. Very shallow to moderately deep, excessively drained to well-drained, gravelly and loamy soils.
Capability unit VIIs-4. Deep, moderately well-drained and well drained, loamy and clayey soils.
Capability unit VIIs-5. Very shallow to shallow, moderately well drained, loamy soils.

Predicted Yields

Table 2 lists the soils of Ward County that are irrigated and gives the predicted average acre yields of the principal crops grown under improved management. The yields given are not presumed to represent the maximum yields obtainable. The figures shown in table 2 are based on information obtained from farmers, on observations, on comparisons made by those familiar with the soils, and on research.

The management needed to obtain yields shown in table 2 is based on the following:

1. Consistent use of soil-improving crops, cover crops and high-residue crops.
2. Proper management of crop residue.
3. Timely application of water and fertilizer in amounts determined by soil and crop needs.
4. Timely tillage, seeding, and harvesting.
5. Timely measures for control of weeds, insects, and plant diseases.
6. Selection of the best, highest producing varieties of crops, timely planting, and proper spacing.
7. Control of soil salinity.

Use of the Soils for Range

By RUDY J. PEDERSON, range conservationist, Soil Conservation Service.

About 92 percent of the land in Ward County is used for grazing by domestic stock and wildlife. This subsection discusses the kinds, extent, and relative value of the soils that are used for range in the county.

Growth of native vegetation in Ward County is variable because of great variations in annual and seasonal rainfall. Growth of forage plants is usually greatest late in summer and in fall, when nearly half of the annual rainfall occurs. Rains are lighter but produce some forage growth in spring. Keeping the number of livestock in balance with the variable and seasonal forage production is important, but is difficult for ranchmen.

The vegetation in the county is primarily of the type classified as semidesert grassland and consists of drought-tolerant short grasses, forbs, and small browse plants. On the deep sand, however, shin oak and the taller grasses and forbs are dominant.

The success of the stockman depends on keeping the adapted forage plants on each soil vigorous, abundant, and productive. This is done primarily by managing the time and intensity of grazing and by applying needed treatment to permit reestablishment and growth of the natural plant community for each soil used as range.

Range sites and condition classes

A range site is a distinctive kind of range that differs from other kinds of range in its potential to produce native plants. A range site is the product of all environ-mental factors responsible for its development. In the absence of abnormal disturbance and physical deterioration, a site supports a climax plant community that is characterized by an association of species different from that of other range sites in kind or proportion of species or in total annual production. Climax vegetation is the stabilized potential plant community that a range site is naturally capable of supporting. This plant community is capable of reproducing itself and does not change greatly as long as the environment remains unchanged.

The plant community changes when it is subjected to continuous heavy grazing. This change varies with the kind of livestock and wildlife. Animals graze the palatable kinds of plants first, and repeatedly. These kinds of plants lose vigor, grow smaller root systems, and produce fewer seeds. If they are continually closely grazed, they die out and are replaced by other, less palatable plants. This process reverses and the climax plants reestablish and increase on deteriorated ranges when proper grazing use and deferred grazing are practiced.

Range condition is the present state of the vegetation of a range site in relation to the climax plant community of that range site. The purpose of determining range condition is to provide an approximate measure of deterioration or improvement that has taken place in the plant community. This provides a basis for determining the degree of improvement needed and feasible. Most of the range in Ward County is in fair condition and has a considerable amount of brush on it.

Four range condition classes are used to express the degree to which the present vegetation composition, expressed in percent, has departed from that of the climax plant community of range sites. The classes show the present condition of the vegetation on a range site in relation to the native vegetation that could grow there. The site is in *excellent condition* if 75 to 100 percent of the present vegetation is the same as the climax vegetation. It is in *good condition* if the percentage is between 51and 75 percent; in *fair condition* if the percentage is between 25 and 50 percent; and in *poor condition* if the percentage is less than 25 percent. A site in poor condition is shown in fig. 10.

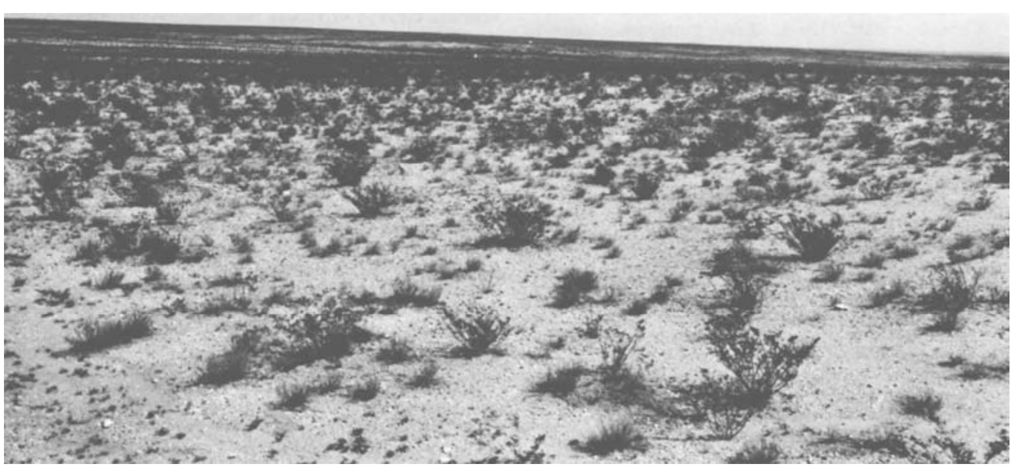

Figure 10.—Gravelly range site in poor condition in an area of Upton gravelly soils, gently undulating.

One of the main objectives of good range management is to improve fair and poor conditions and to maintain excellent or good conditions. If this is done, water is conserved, production is improved, and the soils are protected.

Knowing the range site and range condition is useful in deciding how much improvement can be made and what grazing management or treatment is needed to improve or maintain satisfactory range condition. Natural plant succession is directed toward reestablishment of the climax plant community. Grazing management is designed to permit this to happen to the desired degree. Improvement is accelerated by the appropriate application of such practices as brush control and range seeding on soils where these are feasible.

Descriptions of the range sites

In this subsection the range sites in Ward County are described, the composition of the climax vegetation on each range site is given, and the principal invaders are named. Also given, for each site, is the approximate total annual production in air-dry weight for range in excellent condition in years of favorable and unfavorable growing conditions. Production for favorable years is an approximate average for years when forage growth is above average. Production for unfavorable years is an average for years when growth is below average.

DEEP SAND RANGE SITE

Only Kermit-Dune land association, hummocky, is in this range site. The soil in this site is deep fine sand that is generally associated with sand dunes (fig. 11)

Figure 11.—Deep Sand range site on Kermit-Dune land association, hummocky.

The soil is loose and unstable. Permeability is very rapid. Soil blowing is a severe hazard. Plants that reproduce by rootstocks are dominant.

The climax plant community is a mixture of tall and mid grasses that are associated with shin oak and forbs. Approximate composition, by weight, of the climax plant community is sand bluestem, 10 percent; Havard panicum, 10 percent; giant dropseed, 15 percent; little bluestem, 10 percent; big sandreed, 10 percent; mesa dropseed, 10 percent; perennial three-awn, 5 percent; sand paspalum, 5 percent; Havard oak, 10 percent; sand sage, 5 percent; and annual forbs, 10 percent.

Under continued heavy grazing by cattle, the sand bluestem, Havard panicum, and giant dropseed become thinner. Mesa dropseed, Havard oak, three-awn, sand sage, and annual forbs become thicker. Mesquite, catclaw, and some annuals invade.

If this site is in excellent condition, the total production of air-dry herbage per acre is about 1,000 pounds in favorable years and about 600 pounds in unfavorable years.

DEEP UPLAND RANGE SITE

Hodgins clay loam is the only soil in this range site. This soil is deep, loamy, and nearly level. Permeability is moderate. This is a droughty site, and shallow-rooted, drought-tolerant plants dominate.

The climax vegetation is short and mid grasses. Approximate composition, by weight, of the climax plant community is tobosa, 35 percent; burrograss, 32 percent; plains bristlegrass, 5 percent; ear muhly, 5 percent; alkali sacaton, 10 percent; cane bluestem, 5 percent; Arizona cottontop, 5 percent, and annual forbs, 3 percent.

Under continuous overuse by cattle, the cottontop, cane bluestem, and plains bristlegrass become thicker. The tobosa later becomes thinner and leaves mainly burrograss. Annual weeds are important for forage in years of above-average rainfall.

If this site is in excellent condition, the total annual production of air-dry herbage per acre is about 700 pounds in favorable years and about 400 pounds in unfavorable years.

GRAVELLY RANGE SITE

This site consists of barns and gravelly barns. These soils are on ridges, slopes, and foot slopes. The plants best suited to these soils are those that can utilize moisture quickly and tolerate long periods of drought. Creosotebush is abundant on this site.

The climax plant community consists of grasses, some forbs, and a few shrubs. Approximate composition, by weight, of species in the climax plant community is black grama, 45 percent; plains bristlegrass, 5 percent; bush muhly, 10 percent; perennial three-awn, 10 percent; Halls panicum, 5 percent; slim tridens, 10 percent; grassland croton, 3 percent; black dalea, 3 percent; fluffgrass, 2 percent; range ratany, 3 percent; rough menodora, 2 percent; annual forbs, 1 percent; and gray coldenia, 1 percent.

Under continuous heavy grazing by cattle, the bush muhly, black grama, and plains bristlegrass become thinner. The Halls panicum, annuals, and fluffgrass become thicker. Creosotebush invades. Some mesquite also invades where the soils are deeper.

Range condition improves with rest. Recovery can be speeded up on this site by root plowing and reseeding adapted species.

If this site is in excellent condition, the total annual production of air-dry herbage per acre is about 500 pounds in favorable years and about 200 pounds in unfavorable years.

GYP RANGE SITE

This site consists of loamy soils that vary in depth and are underlain by white gypsic earth. Plants on this site are limited to those that are tolerant of gypsum and dry soils. Grasses that are most successful on this site are those that spread by stolens or rhizomes. The species dominant in the plant community vary as the depth of soil varies.

The climax plant community is grasses and a few shrubs and forbs (fig. 12). Approximate composition, by weight, of the climax plant community is chino grama (variety), 50 percent; gypgrass, 15 percent; black grama, 10 percent; burrograss, 10 percent; alkali sacaton, 5 percent; spike dropseed, 5 percent; fourwing saltbush, 2 percent; allthorn, 1 percent; and coldenia, 2 percent. Mesquite, tarbush, and some annual forbs invade as range condition becomes poorer.

Figure 12.—Gyp range site in poor condition in an area of McCarran soils, nearly level.

Cattle use forage from nearly all the species. The forage, however, is of low quality. Under continuous heavy grazing, the chino grama, black grama, and spike dropseed become thinner. Burrograss and coldenia become thicker Creosotebush is the major invader plant.

If this site is in excellent condition, the total annual production of air-dry herbage per acre is about 440 pounds in favorable years and about 240 pounds in unfavorable years.

It is not feasible to reseed or to control brush on this site.

LAKEBED RANGE SITE

Verhalen clay is the only soil in this site.

This is a deep soil in depressional areas that usually receive runoff water from adjacent areas. The extra water makes this a productive site.

The climax plants are grasses and forbs. The clay soil limits other plants in dry years. Approximate composition, by weight, of the climax plant community is vine-mesquite, 40 percent; white tridens, 15 percent; cane bluestem, 10 percent; tobosa, 30 percent; and annual forbs, 5 percent.

Under continuous heavy grazing by cattle, the white tridens, cane bluestem, and vine-mesquite become thinner. Tobosa becomes thicker.

Stock prefer this range site because grass is green over a longer period. Grazing must be carefully managed to prevent concentration of grazing on this site.

If this site is in excellent condition, the total annual production of air-dry herbage per acre is about 1,000 pounds in favorable years and about 400 pounds in unfavorable years.

SALTY RANGE SITE

This site consists of the clayey and loamy saline soils that are located in and adjacent to the Pecos River Valley. These soils are deep and are affected by salinity. The plant community is limited primarily to salt-tolerant plants. The water table is variable in depth. It permits such plants as saltcedar to thrive.

A complex mixture of salt-tolerant plants is present on this site. The strongly saline areas grow halophytes such as glasswort and pickleweed. Inland saltgrass grows in the low spots, and alkali sacaton dominates in the moderately saline areas. Approximate composition, by weight, of the climax plant community is alkali sacaton, 55 percent; two-flowered trichloris, 5 percent; whiplash pappusgrass, 5 percent; four-wing saltbush, 10 percent; inland saltgrass, 5 percent; Wrights sacaton, 5 percent;

tobosa, 3 percent; tarbush, 2 percent; cane bluestem, 2 percent; jimmyweed, 2 percent; glasswort, 2 percent; pickleweed, 2 percent; and annual forbs, 2 percent.

Under continuous heavy grazing by cattle, the trichloris, whiplash pappus, blue grama, and buffalograss become thinner. The more salt-tolerant plants, such as alkali sacaton, saltgrass, four-wing saltbush, and pickleweed, become thicker. Invaders are mesquite, saltcedar, and annual and perennial forbs.

If this site is in excellent condition, the total annual production of air-dry herbage per acre is about 1,000 pounds in favorable years and about 500 pounds in unfavorable years.

Range seeding on this site is generally not feasible. Proper grazing management is the best means of improving and maintaining good forage plants on this site.

SANDYLAND RANGE SITE

This site consists of moderately deep to deep loamy fine sands. Deep-rooted plants grow well on this site. The climax plant community is a mixture of mid and short grasses, forbs, and some shrubs. Approximate composition, by weight, of the climax plant community is mesa dropseed, 15 percent; giant dropseed, 10 percent; plains bristlegrass, 10 percent; black grama, 25 percent; hooded windmillgrass, 10 percent; reverchon panicum, 10 percent; fall witchgrass, 5 percent; sand dropseed, 2 percent; sand sage, 2 percent; four-wing saltbush, 1 percent; perennial three-awn, 5 percent; perennial forbs, 2 percent; and annual forbs, 3 percent.

Under continued heavy grazing by cattle, black grama, plains bristlegrass, and giant dropseed become thinner. Hooded windmillgrass, sand dropseed, mesa dropseed, and sand sage become thicker. Mesquite, mat sandbur, false buffalograss, and signalgrass invade (fig. 13).

Figure 13.—Sandyland range site. The area is Pyote soils, undulating.

If this site is in excellent condition, total annual production of air-herbage per acre is about 1,500 pounds in favorable years and about 600 pounds in unfavorable years.

This site can be reseeded and brush reduced by mechanical methods.

SANDY LOAM RANGE SITE

This site consists of nearly level to gently sloping, shallow to deep fine sandy loams.

The climax plant community is primarily warm-season bunchgrass and a few forbs. Approximate composition, by weight, of the climax plant community is black grama, 40 percent; mesa dropseed, 8 percent; blue grama, 5 percent; plains bristlegrass, 15 percent; bush muhly, 5 percent; fall witchgrass, 10 percent; perennial three-awn, 5 percent; Arizona cottontop, 5 percent; annual forbs, 5 percent; and four-wing saltbush, 2 percent.

Under continuous heavy use by cattle, the bristlegrass, cottontop, blue grama, and mesa dropseed become thicker and then later become thinner. Mesquite invades this site. Broom snakeweed and creosotebush are also common invaders.

If this site is in excellent condition, the total annual production of air-dry herbage per acre is about 1,500 pounds in favorable years and about 500 pounds in unfavorable years.

Brush control and range seeding can be done on this site.

SHALLOW SANDY LOAM RANGE SITE

The soils of this site are nearly level, shallow, fine sandy loam over cemented and indurated caliche. Shallow-rooted, quick-maturing, drought-resistant grasses are best suited to the site.

The climax plant community is grasses and a few shrubs. Approximate composition, by weight, of the climax plant community is black grama, 60 percent; slim tridens, 10 percent; mesa dropseed, 5 percent; plains bristlegrass, 5 percent; purple three-awn, 3 percent; bush muhly, 5 percent; Halls panicum, 3 percent; ephedra, 1 percent; rough menodora, 2 percent; annual forbs, 3 percent; catclaw acacia, 1 percent; and perennial forbs, 2 percent.

Under continuous heavy grazing by cattle, the slim tridens, bristlegrass, menodora, and bush muhly become thinner. Black grama and mesa dropseed become thicker and later become thinner. Creosotebush and mesquite invade this site.

Grazing should be managed to permit seed to mature prior to grazing.

If this site is in excellent condition, the total annual production of air-dry herbage is about 1,500 in favorable years and about 1,300 pounds in unfavorable years.

It is possible to control the brush and reseed this site.

Use of the Soils for Wildlife

By JAMES HENSON, biologist, Soil Conservation Service.

The principal kinds of wildlife in Ward County are antelope, fox squirrel, bobwhite quail, scaled (blue) quail, dove, cottontail rabbits, jackrabbits, small rodents, and numerous kinds of nongame birds. Also present are raccoons, foxes, skunks, and other furbearers. The predators commonly present are bobcats and coyotes. Intermittent lakes, the Pecos River, and grainfields attract ducks and geese during migration. The Pecos River has some fish. Fish and wildlife resources are of minor economic importance to landowners in this county.

Successful management of wildlife on any tract of land requires, among other things, that food, cover, and water be available in a suitable combination. Lack of any one of these necessities, unfavorable balance between them, or inadequate distribution of them may severely limit or account for the absence of desired wildlife species. Information on soils provides a valuable tool in creating, improving, or maintaining suitable food, cover, and water for wildlife.

Most wildlife habitats are managed by planting suitable vegetation, by manipulating existing vegetation to bring about natural establishment, by increasing or improving desired plants, or by combination of such measures. The influence of a soil on the growth of plants is known for many kinds of plants and can be inferred for others from a knowledge of the characteristics and behavior of the various kinds of soil. In addition, water areas can be created or natural ones improved as wildlife habitats. Information on soils is useful for these purposes.

Soil interpretations for wildlife habitat serve a variety of purposes. They are an aid in selecting the more suitable sites for various kinds of management. They serve as indicators of the level of management intensity needed to achieve satisfactory results. They also serve as a means of showing why it may not be feasible generally to manage a particular area for a given kind of wildlife.

These interpretations also may serve in broad-scale planning of wildlife management areas, parks, and nature areas, or for acquiring wildlife lands.

Soil properties that affect the growth of wildlife habitat are (1) thickness of soil useful to crops, (2) surface texture, (3) available water capacity, (4) wetness, (5) surface stoniness or rockiness, (6) hazard of flooding, and (7) slope.

The soil areas shown on the soil survey maps are rated without regard to positional relationships with adjoining delineated areas. The size, shape, or location of the outlined area does not affect the rating. Certain influences on habitats, such as elevation and aspect, must be appraised on the site.

In table 3 the soils of Ward County are rated for their suitability for six elements of wildlife habitat and for three kinds of wildlife. These ratings are based upon limitations imposed by the characteristics or behavior of the soils. Four levels of suitability are recognized. Numerical ratings of 1 to 4 indicate the degree of soil suitability for a given habitat element. A rating of 1 means well suited and indicates that habitats generally are easily created, improved, or maintained; that the soil has few or no limitations that affect management; and that satisfactory results can be expected. A rating of 2 means suited and indicates that habitats can be created, improved, or maintained in most places; that the soil has moderate limitations that affect management; and that a moderate intensity of management and fairly frequent attention may be required for satisfactory results. A rating of 3 means poorly suited and indicates that habitats can be created, improved, or maintained in most places; that the soil has rather severe limitations; that habitat management is difficult and expensive and requires intensive effort; and that results are not always satisfactory. For short-term use, soils rated 3 may provide easy establishment and temporary value. A rating of 4 means unsuited and indicates that the soil limitation is so extreme that it is impractical, if not impossible, to manage the designated habitat element. Unsatisfactory results are probable

The six habitat elements rated in table 3 are defined in the following paragraphs.

Grain and seed crops are grains or seed-producing annuals planted to produce food for wildlife. Examples are rye, sorghum, millet, barley, wheat, oats, and sunflower. Irrigation is required to produce food for wildlife.

Grasses and legumes are domestic perennial grasses and legumes that are established by planting and that furnish food and cover for wildlife. Examples are bahia, ryegrass, fescue, and panicgrasses. Legumes are plants such as alfalfa and sweetclover. Irrigation is required to produce food and cover for wildlife.

Wild herbaceous upland plants are perennial grasses, forbs, and weeds that provide food and cover for wildlife. Examples of these are wild carrots, two-flowered trichloris, cane bluestems, vine-mesquite, tobosa, and bristlegrass.

Hardwood trees and shrubs are nonconiferous trees, shrubs, and woody vines that produce fruits, nuts, buds or foliage (browse) used extensively as food by wildlife. These plants commonly become established through natural processed but may be planted. Examples are shin oak, mesquite, allthorn, yucca, catclaw, butterflybush, senecio, four-wing, greenbrier, some species of cactus, and desert willow.

Wetland food and cover plants are annual and perennial wild hebaceous plants in moist to wet sites, exclusive of submerged or floating aquatics, that produce food or cover that is extensively and dominantly used by wetland forms of wildlife. Examples are barnyardgrass, sedges, sourdock, pickleweed, and cattails

Shallow water developments are low dikes and water control structures established to create habitat principally for waterfowl. They may be designed so that they can be drained, planted, and flooded or they may be used as permanent impoundments to grow submerged aquatics. Both fresh water and brackish water situations are included.

The three general kinds of wildlife rated in table 3 are defined in the following paragraphs.

Open-land wildlife consists of birds and mammals that normally frequent cropland, pastures, and areas overgrown with grasses, herbs, and shrubby growth. Examples of this kind of wildlife are quail, cottontail rabbits, jackrabbits, and sparrows.

Brushland wildlife consists of birds and mammals that normally frequent areas of hardwoods trees and shrubs. Examples of brushland wildlife are antelope, squirrels, and raccoons.

Wetland wildlife consists of birds and mammals that normally frequent such areas as playa lakes, streams, and ditches. Examples of this kind of wildlife are ducks, geese, and snipe.

Engineering Uses of the Soils

By NELSON O. SALCH, civil engineer, Soil Conservation Service.

This section provides information of special interest to engineers, contractors, farmers, and others who use soil as structural material or as foundation material upon which structures are built. In this section are discussed those properties of the soils that affect construction and maintenance of roads and airports, pipelines, building foundations, water storage facilities, erosion control structures, drainage systems, and sewage disposal systems. Among the soil properties most important in engineering are permeability, compressibility, shear strength, density, shrink-swell potential, available water capacity, grain-size distribution, plasticity, and reaction.

Information concerning these and related soil properties is furnished in tables 4, 5, 6, and 7. The estimates and interpretations of soil properties in these tables can be used in—

1. Planning drainage systems, farm ponds, irrigation systems, diversion terraces, and other structures for controlling water and conserving the soil.
2. Selecting potential locations for highways, airports, pipelines, and underground cables.
3. Locating probable sources of sand, gravel, caliche, or rock suitable for use as construction material.
4. Selecting potential industrial, commercial, recreational, and residential areas.

The engineering interpretations reported here do not eliminate the need for sampling and testing at the site of specific engineering works involving heavy loads and where the excavations are deeper that the depths of layers here reported. The estimated values for traffic-supporting capacity expressed in words should not be assigned specific values. It should also be noted that small areas of other soils and contrasting situations are included in each mapping unit that may have different engineering properties than those listed. Even in these situations, however, the soil map is useful in planning for detailed field investigations and for indicating the kinds of problems that may be expected.

Some terms used by soil scientists may be unfamiliar to engineers and some words have different meanings in soil science than they have in engineering. Among the terms that have special meaning in soil science are sand, silt, subsoil, and horizon. These and other terms are defined in the Glossary at the back of this survey.

Engineering classification systems

The two systems most commonly used in classifying samples of soil horizons for engineering are the AASHO system (3), adopted by the American Association of State Highway Officials, and the Unified system (12), used by SCS engineers, Department of Defense, and others.

The AASHO system is used to classify soils according to those properties that affect use in highway construction. In this system, a soil is placed in one of seven basic groups ranging from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A-1 are gravelly soils of high bearing strength or the best soils for subgrade (foundation), and at the other extreme, A-7, are clay soils that have low strength when wet. The best soils for subgrade are therefore classified as A-1, the next best A-2, and so on to class A4, the poorest soils for subgrade. When laboratory data are available to justify a further breakdown, the A-1, A-2, and A-7 groups are divided as follows: A-1-a, A-1-b; A-2-4, A-2-5, A-2-6, A-2-7; and A-7-5, A-7-6. If soil material is near a classification boundary it is given a symbol showing both classes, for example, A-2 or A-4. Within each group, the relative engineering value of a soil material can be indicated by a group index number. Group indexes range from 0 for the best material to 20 for the poorest. The AASHO classification for tested soils, with index numbers in parentheses, is shown in table 6; the estimated classification for all soils mapped in the survey area is given in table 4.

In the Unified system soils are classified according to particle-size distribution, plasticity, liquid limit, and organic-matter content. Soils are grouped in 15 classes. There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes are designated by symbols for both classes; for example MH-CH.

Estimated engineering properties

Table 4 provides estimates of soil properties important to engineering. The estimates are based on field classification and descriptions, physical and chemical tests of selected representative samples, test data from comparable soils in adjacent areas, and detailed experience in working with the individual kind of soil in the survey area.

Depth to bedrock indicates the depth at which consolidated materials may be found. The column showing depth to seasonal high water table was omitted because the water table is well below the depth to which the soils were examined. Improper irrigation may result in a temporary high water table in the Harkey and Patrole soils.

Hydrologic soil groups give the runoff potential from rainfall. Four major soil groups are used. The soils are classified on the basis of intake of water at the end of long-duration storms occurring after prior wetting and opportunity for swelling, and without the protective effects of vegetation.

The major soil groups are:

Group A.—Soils that have a high infiltration rate even when thoroughly wetted. These consist chiefly of deep, well-drained to excessively drained sand or gravel. These soils have a high rate of water transmission, which results in a low runoff potential.

Group B.—Soils that have a moderate infiltration rate when thoroughly wetted. These consist chiefly of moderately deep to deep, moderately well drained to well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C.—Soils that have a slow infiltration rate when thoroughly wetted. These consist chiefly of moderately deep to deep, moderately well drained to well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group D.—Soils that have a very slow infiltration rate when thoroughly wetted. These consist chiefly of clay soils that have a high swelling potential, of soils that have a permanent high water table, of soils that have a claypan or clay layer at or near the surface, and of shallow soils underlain by nearly impervious material. These soils have a very slow rate of water transmission.

USDA texture is determined by the relative proportions of sand, silt, and clay in soil material that is less than 2.0 millimeters in diameter. Sand, silt, clay, and some of the other terms used in the USDA textural classification are defined in the Glossary in the back of this survey.

Permeability relates only to movement of water down-ward through undisturbed and uncompacted soil. It does not include lateral seepage. The estimates are based on structure and porosity of the soil. Plowpans, surface crusts, and other features resulting from use of the soils are not considered.

Available water capacity is the amount of water a soil can hold and make available to plants. It is the numerical difference between the percentage of water at field capacity and the percentage of water at the time plants wilt. The rate is expressed as inches of water per inch of soil depth.

Reaction is the degree of acidity or alkalinity of a soil, expressed as a pH value. Relative terms to describe soil reaction are explained in the Glossary.

Salinity of the soil is based on the electrical conductivity of the saturated soil extract, as expressed in millimhos per centimeter at 25° C. Salinity affects the suitability of a soil for crop production, its stability when used as a construction material, and its corrosiveness to other materials.

Shrink-swell potential is an indication of the volume change to be expected of the soil material with changes in moisture content. Shrinking and swelling of soils cause much damage to building foundations, roads, and other structures. A high shrink-swell potential indicates hazards to the maintenance of structures constructed in, on, or with such materials.

Interpretations of engineering properties

Table 5 contains selected information useful to engineers and others who plan to use soil material in construction of highways, farm facilities, drainage systems, irrigation systems, and terraces and diversions. The ratings and other interpretations in this table are based on estimated engineering properties of the soils in table 4; on available test data, including those in table 6; and on field experience. While, strictly, the information applies only to soil depths indicated in table 4, it is reasonably reliable to depths of about 6 feet for most soils, and to several feet more for some.

Topsoil is a term used to designate a fertile soil or soil material, ordinarily rich in organic matter, used as a topdressing for lawns, gardens, roadbanks, and the like. The ratings indicate suitability for such use.

Road fill is material used to build embankments. The ratings indicate performance of soil material moved from borrow areas for these purposes.

Sand and gravel ratings are based on the probability that delineated areas of the soil contain deposits of sand and gravel. The ratings do not indicate quality or size of the deposits.

Farm pond reservoir areas are affected mainly by seepage loss of water, and the soil features are those that influence such seepage.

Farm pond embankments serve as dams. The soil features of both subsoil and substratum are those important to the use of soils for constructing embankments.

Agricultural drainage is influenced by those features and qualities of the soil that affect the installation and performance of surface and subsurface drainage systems.

Irrigation suitability depends largely on water intake rate, available water capacity, depth of soil, slope, and susceptibility to water erosion, soil blowing, and flooding.

Terraces and diversions are channels that divert water. The pertinent soil features are those that influence stability and that affect use of the soil as construction material.

Engineering test data

Table 6 contains the results of engineering tests performed by the Texas Highway Department on several soils in Ward County.

The table shows the specific location where samples were taken, the depth to which sampling was done, and the results of tests to determine particle-size distribution and other properties significant in soil engineering.

Linear shrinkage is the decrease in one dimension, expressed as a percentage of the original dimension, of the soil mass when the moisture content is reduced from the given value to the shrinkage limit. It is used to give some indication of the amount of cracking that will take place in a soil as a result of drying.

Shrinkage ratio is the ratio of a given volume change, expressed as a percentage of the dry volume, to the corresponding change in water content above the shrinkage limit, expressed as a percentage of the weight of the oven-dried soil.

Shrinkage limit is the maximum water content at which a reduction in water content will not cause a decrease in volume of the soil mass. Since clay is the major soil fraction that causes shrinkage, the shrinkage limit of a soil is a general index of clay content and will, in general, decrease with an increase in clay content.

Mechanical analyses show the percentages, by weight, of soil particles that would pass sieves of specified sizes. Sand and other coarser materials do not pass through the No. 200 sieve. Silt and clay pass through the No. 200 sieve. Silt is that material larger than 0.002 millimeter in diameter that passes through the No. 200 sieve, and clay is that fraction passing through the No. 200 sieve that is smaller than 0.002 millimeter in diameter. The clay fraction was determined by the hydrometer method rather than by the pipette method most soil scientists use in determining the clay in soil samples.

Liquid limit and plasticity index indicate the effect of water on the strength and consistence of soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from a solid to a plastic state. If the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material passes from solid to plastic. The liquid limit is the moisture content at which the material changes from plastic to liquid. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a material is plastic.

The AASHO and Unified classifications have been explained earlier in the engineering section.

Interpretations for town and country planning

Table 7 contains information useful to engineers, contractors, and others who use the soil for residential developments, recreation areas, and other community needs. The ratings and other interpretations in this table are based on estimated engineering properties of the soils in the table, on available test data, and on field experience.

Roads and streets are influenced by features of the undisturbed soil that affect construction and maintenance of roads and streets. The soil features, favorable as well as unfavorable, are the principal ones that affect geographic location of roads and streets.

Foundations for low buildings are affected chiefly by features of the undisturbed soil that influence its capacity to support low building that have normal foundation loads.

Septic tank filter fields are affected by permeability, location of water table, and susceptibility to flooding.

Sewage lagoons are influenced chiefly by soil features such as permeability, location of water table, and slope.

Sanitary landfills are affected by depth of the fill, availability of cover material, and hazard of pollution.

Camp areas are those areas to be used intensively for tents and small camp trailers and the accompanying activities of outdoor living. Little site preparation is normally required other than shaping and leveling for tent and parking areas. These areas are subject to heavy foot traffic and limited vehicular traffic. The assumption is made that good vegetative cover can be established and maintained. The best soils have mild slopes. good drainage, a surface free of rocks and coarse fragments; freedom from flooding during periods of heavy use; and a surface layer that is firm, even after rains, but not dusty when dry.

Picnic areas refer to park-type picnic areas. These areas are subject to heavy foot traffic, but most vehicular traffic is confined to access roads. Preparation of an area consists of leveling sites for tables and fireplaces and building access roads. The assumption is made that good vegetative cover can be established and maintained. Soil limitations for waste disposal and for playgrounds are treated as separate items. Important soil properties affecting this use are wetness, flooding hazard, slope, surface texture, and rockiness. Prime requirements for this use are freedom from muddiness and dustiness. Strong slopes and rockiness greatly increase the cost of site leveling and building access roads.

Paths and trails apply to the use of soils for local and cross-country foot paths and trails and for bridle paths. It is assumed that the soils would be used in their natural state and that little or no cutting and filling would be done in design and layout of the trails. Soil properties that affect paths and trails are those that affect foot traffic, such as wetness, surface texture, and coarse fragments, and those that affect design, construction, and maintenance, such as slope, rockiness, or stoniness. Safety features such as sheer cliffs, slippery rocks, and the like were not considered.

Playgrounds are those areas that are intensively used for play, such as baseball, football, badminton, and other organized games. These areas are subject to intensive foot traffic. The assumption is made that good vegetative cover can be established and maintained. Soil properties that affect the use of the soil for playgrounds are those that affect intensive foot traffic and those that affect design, construction, and maintenance. The best soils for playgrounds have a nearly level surface free of coarse fragments and rock outcrops; good water drainage; freedom from flooding during periods of heavy use; and a surface layer that is firm, even after rains, and is not dusty when dry. Depth to rock is an important consideration on uneven slopes that require grading and leveling.

Uncoated steel buried in the soil corrodes as a result of an electrochemical process that converts iron into its ions. Soil drainage, texture, and electrical conductivity and resistivity are the major factors affecting corrosion. Rating is based on soil conditions at a 4-foot depth.

Concrete placed in soil may deteriorate to varying degrees. Soil texture, acidity, and the amount of sodium, magnesium sulfate, or sodium chloride in the soil are the major factors affecting corrosion. A column for concrete was not included in table 7, because all the soils of Ward County are rated low in corrosivity of concrete.

Formation and Classification of the Soils

This section discusses the five factors of soil formation. Then it discusses the system of classifying soils and places each soil represented in the county in the major categories of that system.

Factors of Soil Formation

The properties that characterize a particular soil are a result of the influence of a particular combination of several factors of soil formation. The factors are (1) the physical and mineralogical composition of the parent material; (2) the climate under which the soil material has accumulated and has existed since accumulation; (3) the plant and animal life on and in the soil; (4) topography, or lay of the land; and (5) the length of time the forces of soil formation have acted on the soil material.

Climate

The main climatic factors that influence soil formation are temperature, amount of precipitation, and seasonal distribution of precipitation. Climate directly affects the soil through its influence on weathering, leaching of carbonates, translocation of clay, reduction and transfer of iron, and rate of erosion. Climate is also directly responsible for the kind and amount of vegetation, which is a direct reflection on the amount and distribution of organic matter in the soil.

The climate of Ward County is subtropical semidesert. It is uniform throughout the county. The summers are hot, and the winters are cool. The major part of the annual precipitation occurs in the period from May through October. Most of this rainfall is in the form of thundershowers of high intensity. These high-intensity rains cause soil erosion. Late in winter and in spring, high winds cause duststorms that remove the soil in one area and deposit it in another area. The humidity is very low, and evaporation is high.

Topography

Topography, or relief, affects soil formation through its influence on drainage, erosion, plant cover, and soil temperature. The topography of Ward County ranges from nearly level on the flood plain to strongly sloping on the uplands.

The nearly level to sloping soils that formed on uplands are underlain by deposits of caliche, because water entered the soil and leached the carbonates so that they accumulated in the lower horizons. These soils are the Wickett, Kinco, Upton, and Delnorte.

The soils that have the steeper slopes are shallow because geologic erosion has kept pace with the rate of soil formation. The soils that have lesser slopes or are concave are deeper because soil formation has been faster than geologic erosion.

Time

Time, usually a long time, is required for the formation of soils that have distinct horizons. The differences in length of time that parent materials have been in place are commonly reflected in the degree of development of the soil profile.

The soils in Ward County range from young to old. The young soils have little profile development, and the old soils have well-expressed soil horizons. The soils on the Pecos River flood plain are examples of young soils. If it were not for dams and levees on the Pecos River, these soils would still be receiving sediments as a result of floods.

Soils such as the Ima, McCarran, and Hodgins are a little older than the soils on flood plains. These soils formed in older alluvium that is now in higher lying areas. Plant roots have formed some soil structure, and carbonates have accumulated in the form of concretions, films, and threads in the lower layers. Older soils, such as the Wickett, Delnorte, Sharvana, Kinco, and Upton, have thick, soft to very hard accumulations of caliche. This indicates that they had to have been there for a long time for this quantity of carbonates to have accumulated.

Living organisms

Plants, micro-organisms, earthworms, rodents, and other forms of life on or in the soil are active in the soil-forming processes. They provide organic matter, help to decompose plant residue, affect the chemistry of the soil, and hasten soil formation. Living organisms also help to convert plant nutrients to a form that is more readily available to plants. Some organisms obscure horizon differentiation by churning or mixing the soil.

Vegetation, dominantly desert shrubs and grasses, has affected soil formation in Ward County more than the other living organisms. The shrub vegetation produced soils that are generally lower in organic matter than those soils that formed under grasses.

Parent material

Parent material is the unconsolidated mass from which a soil is formed. It determines the limits of the chemical and mineralogical composition of the soils.

Ward County is underlain by eolian sands, caliche, calcareous and gypsiferous earths, sandstone, and alluvial sediments.

Classification of the Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationships to one another and to the whole environment, and to develop principles that help us in understanding their behavior and their response to manipulation. First through classification, and then through the use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

Thus, in classification, soils are placed in narrow categories that are used in detailed soil surveys so that knowledge about the soils can be organized and used in managing farms, fields, and range; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (*4*) and later revised (*9*). The system currently used was adopted for general use by the National Cooperative Soil Survey in 1965. The current system is under continual study, and readers who are interested in developments in this system should read the latest literature available (*7, 11)*.

In table 8, each soil series in Ward County is placed in its family, subgroup, and order of the current classification system. There are four soil orders in Ward County—Aridisols, Entisols, Mollisols, and Vertisols.

Aridisols have a light-colored surface layer, are low in organic matter, and have horizons of calcium carbonate or gypsum accumulation.

Entisols are recent soils that do not have natural genetic horizons or that have only the beginnings of genetic horizons.

Mollisols have a dark-colored surface layer, have a high base saturation, have structure, have a high content of organic matter and are not hard when dry.

Vertisols crack when dry and swell when wet, and a natural churning or inversion takes place because of the high clay content of the soil.

Additional Facts About the County

This section briefly discusses the history and development of Ward County. Then the geology and the climate are described.

History and Development

In 1881 the Texas and Pacific Railroad was completed across Ward County. Even before the 529,280 acres of rangeland was organized into Ward County, ranchers had arrived in the 1880's to grow beef. Cattle were soon shipped to market by railroad.

In July 1889 a group of Texas and California investors chartered the Pioneer Canal Company. The purpose of the company was to promote irrigation by zoning, constructing, maintaining, and operating ditches, canals, dams, flumes, feeders, and reservoirs in Reeves and Ward Counties. Fourteen months later the Grandfalls Irrigation was organized.

Settlers both in Barstow and Grandfalls produced fine grapes on what is thought to be Arno soils. Melons, all types of vegetables, almonds, peaches, apples, pears, and strawberries flourished at Barstow on the Gila, Harkey, and Patrole soils, and also at Grandfalls. Alfalfa was and is still a major crop grown on the Gila and Toyah soils. Cotton has been a commercial success also.

In 1894, floods washed out the lower falls at Grandfalls. Then a brush diversion dam was built on the upper falls, and canals from that area were connected to the old network for irrigation. In 1904 heavy rains caused the McMillan dam to break, so that floodwater poured down into the valley around Barstow, washed out flumes, and covered the soil with salty water.

The Pioneer Canal Company in Barstow was reorganized in 1913 and is now Ward County Irrigation District No. 1.

The Grandfalls Irrigation Company was reorganized a number of times and is presently Ward County Water Improvement District No. 2, organized in 1917.

Ward County Water Improvement District No. 3 was organized in 1918 for the Cedarvale area north of Barstow.

Damming of the upper Pecos in New Mexico plus a drought in 1916 reduced the amount of water available for irrigation to farmers in Ward County. A movement was begun to build a dam on the upper Pecos in Texas. In 1936 the Red Bluff Dam was completed. Good irrigated crops were grown once again in 1937.

Cattle, bees, fancy foods, vegetables, fruits, row crops, and horses have all been farm products of Ward County.

The variable amount of rainfall and irrigation water has given Ward County a history of booms and lean years.

Growing of salt-tolerant grasses is now encouraged. If an adequate supply of water of suitable quality can be made available, irrigated farming could again flourish in Ward County.

Geology

By JOSEPH W. MUSSEY, geologist, Texas Highway Department.

The subsurface of Ward County is divided almost in half by a southward-trending structural high. The Central Basin Platform (*5*) is to the east, and the Delaware Basin is to the west. Around the margin of the Central Basin Platform, marine organisms built the vast Capitan Reef during the Guadalupian part of the Permian Period. This reef, and the rocks associated with it have proved prolific oil producers.

Precambrian granite underlies the deep, gas-producing Ellenberger Group (*6*) of the Cambrian and Ordovician Systems. Silurian, Devonian, Mississippian, and

Pennsylvanian rocks are also present, but are not ex-posed in Ward County. These older rocks are faulted, up to the east and down to the west.

Exposed in the western part of the county, and south along the curve of the Pecos River, are rocks of Permian, Triassic, and Cretaceous age. Most extensive is the Triassic Santa Rosa Sandstone; sparse and not easily discerned are the Permian Dewey Lake Red Beds and the Cretaceous Yearwood Formation.

The Yearwood Formation is composed of limestone and basal conglomerate. This rock makes a very good flexible base, of high triaxial strength, for highway construction.

Before the turn of the century, a rock quarry was in operation on Barstow Hill, east of Barstow. Santa Rosa Sandstone was quarried and shipped by rail to be used in buildings in Texas and elsewhere. The stone proved to be a poor construction material, because exposure and weathering resulted in rapid exfoliation.

A structural sag, to the west, can be observed in the Santa Rosa Sandstone on Barstow Hill. The beds dip steeply and are fractured locally. Most of the sag (*8*) is probably the result of solution, by ground water, of the Permian evaporites in the Rustler Formation down to the top of the Delaware Mountain Group. This slump-age may have begun during the Triassic Period (*2*). Movement along the Capitan Ridge fractured the late Permian cover and opened channels for circulating unsaturated waters to attack the soluble salts. Escape of the saturated (*1*) water must have been to the southeast across the Edwards Plateau.

The solution resulted in the subsidence of both the Rustler Formation and young rocks. A trough was formed during subsidence and was filled with Cenozoic alluvium.

Existence of the slumpage trough is in evidence south of Pyote and along the Pecos River. This trough once formed a marsh and freshwater lake in Ward and Reeves Counties. Far from any existing or ancient river bed, unfossilized skeletons of fresh-water fish and mussel shells are found in the Cenozoic alluvium. Bones of large extinct mammals have been uncovered in the gravel and clays of the alluvium.

The Pecos River watershed provided water to the lake. At the close of the Pleistocene Epoch, as the lake receded and dried up, concentration of the dissolved minerals in the evaporating waters caused gypsum to be deposited over a large area.

Sand is a very distinct surface characteristic in Ward County. Large sand dunes exist in the eastern and north-western parts of the county, and the Santa Rosa Sandstone outcrops produced these vast amounts of sand. These outcrops start in the northwestern part of Ward County, at its intersection with Loving and Winkler Counties, and curve southward along the Pecos River into Crane County.

Upon release from the parent rock, the sand was transported across the country by prevailing westerly post-Pleistocene winds.

The sand grains are coated with red iron oxide, but where the sands have been repeatedly reworked, as have the sand dunes east of Monahans, the coating is absent. Frosted and pitted grain surfaces give the Monahans Sand Dunes a cream color. These sands are more than 30 miles from the parent rock outcrops.

A nearby static, slow-moving, or secondary, series of sand dunes exists in the northwestern part of Ward County. Speculation is varied as to why the sand dunes have not moved eastward. Dune migration may be controlled by a critical elevation of the dune crest, lower wind velocities over a period of time, or late emergence of the outcrop. Also, a secondary migration may have begun. Whatever the case may be, the dunes are still associated with the parent rock.

Ground water is available in Ward County. The quality meets requirements for municipal use, and the quantity is adequate for industrial and farm purposes.

Much of the recharge of the aquifer in the western part of Ward County will come from the alluvium in Reeves County. As the water derived through local precipitation is pumped out, underground recharge from the west will increase the content of dissolved solids in the water of Ward County.

Climate

By ROBERT B. ORTON, climatologist for Texas, National Weather Service, U.S. Department of Commerce.

Ward County has a subtropical, semidesert climate. Rainfall throughout the year is light and insufficient for any growth except desert vegetation. Dry periods lasting several months are not unusual. Prevailing winds are southerly to south-southeasterly throughout the year except in February and December, when southwesterly winds predominate.

Daytime temperatures in winter are mild, and the average daily maximum is about 61° F. Normally, night temperatures drop to 32° or below about 2 nights in 3 during December and January. Winters are characterized by frequent cold spells lasting 36 to 72 hours and followed by rapid warming. The sun shines about 70 percent of the total time possible during winter.

Daytime temperatures in summer are hot, and the average daily maximum is about 96.5°. Highs above 100° are common, but when temperatures are high, the relative humidity is generally low. The average daily minimum in summer is about 70°.

Late in winter and early in spring, duststorms occur frequently. The loose sandy soil, sparsely covered with grass and desert vegetation, is picked up easily by the strong winds. Dust in many of these storms remains suspended in the air for several days after the storm has passed. The sky is occasionally obscured by dust, but in most storms visibility ranges from 1 to 3 miles.

About three-fourths of the total precipitation occurs from May through October. Most of this falls from brief, but at times heavy, thundershowers. Total rainfall from November through April is normally less than 3 inches.

Small amounts of snow fall nearly every winter, but snow cover rarely amounts to more than an inch and seldom remains on the ground for more than a few hours.

The growing season (freeze-free period) in Ward County averages 223 days. The average date of the last freeze in spring is April 1, and the average date of the first freeze in fall is November 10.

Violent wind or hailstorms may accompany the thunderstorms that occur late in spring and early in summer. Only two tornadoes are known to have touched ground in Ward County during the period 1959-66.

Average annual relative humidity is about 65 percent at 6 a.m., 40 percent at noon, and 35 percent at 6 p.m. Average annual lake evaporation is estimated to be 76 inches. The area receives about 76 percent of the total possible sunshine annually, and there is only slight seasonal variation.

Seven years of precipitation and temperature data (1960-66) are available for Monahans, in Ward County. Since this period is not sufficient for the preparation of a reliable statistical summary of the climate, data from Wink, Texas, in Winkler County, have been included (table 9). These should be reasonably representative of the climatic characteristics of Ward County.

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Glossary

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates such as crumbs, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alkali soil. Generally, a highly alkaline soil. Specifically, an alkali soil has so high a degree of alkalinity (pH 8.5 or higher) or so high a percentage of exchangeable sodium (15 percent or more of the total exchangeable bases), or both, that the growth of most crop plants is low from this cause.

Alluvium. Soil material, such as sand, silt, or clay that has been deposited on land by streams.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Caliche. A more or less cemented deposit of calcium carbonate in many soils of warm-temperate areas, as in the Southwestern States. The material may consist of soft, thin layers in the soil or of hard, thick beds just beneath the solum, or it may be exposed at the surface by erosion.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.

Claypan. A compact, slowly permeable soil horizon that contains more clay than the horizon above and below it. A claypan is commonly hard when dry and plastic or stiff when wet.

Colluvium. Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a “wire” when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and have mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and some soils commonly have mottling at a depth below 6 to 16 inches.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Eolian soil material. Earthy parent material accumulated through wind action; commonly refers to sandy material in dunes or to loess in blankets on the surface.

Erosion. The wearing away of the land surface by wind (sand-blast), running water, and other geological agents.

Flood plain. Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.

Hardpan. A hardened or cemented soil horizon, or layer. The soil material may be sandy or clayey, and it may be cemented by iron oxide, silica, calcium carbonate, or other substance.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Irrigation. Application of water to soils to assist in production of crops. Methods of irrigation are—

Border.—Water is applied at the upper end of a strip in which the lateral flow of water is controlled by small earth ridges called border dikes, or borders.

Basin.—Water is applied rapidly to relatively level plots surrounded by levees or dikes.

Controlled flooding.—Water is released at intervals from closely spaced field ditches and distributed uniformly over the field.

Corrugation.—Water is applied to small, closely spaced furrows or ditches in fields of close-growing crops, or in orchards, to confine the flow of water to one direction.

Furrow.—Water is applied in small ditches made by cultivation implements used for tree and row crops.

Sprinkler.—Water is sprayed over the soil surface through pipes or nozzles from a pressure system.

Subirrigation.—Water is applied in open ditches or tile lines until the water table is raised enough to wet the soil.

Wild flooding.—Irrigation water, released at high points, flows onto the field without controlled distribution.

Phase, soil. A subdivision of a soil, series, or other unit in the soil classification system made because of differences in the soil that affect its management but do not affect its classification in the natural landscape. A soil type, for example, may be divided into phases because of differences in slope, stoniness, thickness, or some other characteristic that affects its management but not its behavior in the natural landscape.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Relief. The elevations or inequalities of a land surface, considered collectively.

Saline soil. A soil that contains soluble salts in amounts that impair growth of plants but that does not contain excess exchangeable sodium. Salinity class and conductivity of saturation extract of the soil are:

Salinity Rating	Salinity as *Millimhos per cm*
None	Less than 2.0
Low	2.0 to 4.0
Moderate	4.0 to 8.0
High	8.0 to 16.0
Very high	More than 16.0

Sand. Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Series, soil. A group of soils developed from a particular type of parent material and having genetic horizons that, except for texture of the surface layer, are similar in differentiating characteristics and in arrangement in the profile.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular. Structureless* soils are either *single grain* (each grain by itself, as in dune sand) or *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sandy, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay.* The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

Tables

The tables in this soil survey contain information that affects land use planning in this survey area. More current data tables may be available from the Web Soil Survey at the Tabular Data tab.

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